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PROBLEM ANALYSIS

for forest-management studies:

SPRUCE-FIR (and associated hardwoods) REGION

OF MAINE AND NEW HAMPSHIRE

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Northeastern
Forest Experiment Station
Upper Darby, Pa.
V.L. Harper, Director

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FOREWORD

PROBLEM ANALYSES that provide the basis for formulating the Station's research program in forest and watershed management are carried on in two stages. First is the broad analysis of the problems of the Northeast, which has as its primary purpose a determination of the extent and location of problem areas that need concentrated research attack. As a result of such an analysis the spruce-fir region of Maine and northern New Hampshire was designated as one such area. It has distinctive conditions in terms of forest types, soils, watersheds, utilization problems, and general land- and water-management problems that set it apart from other problem areas in New England such as the white pine and northern hardwood regions.

The next stage of the analysis is the more detailed analysis of problems within a given area. This report presents such an analysis for the spruce-fir region of Maine and New Hampshire with respect to forest-management problems. It was made by T. F. McLintock, in charge of our Penobscot Research Center for that problem area.

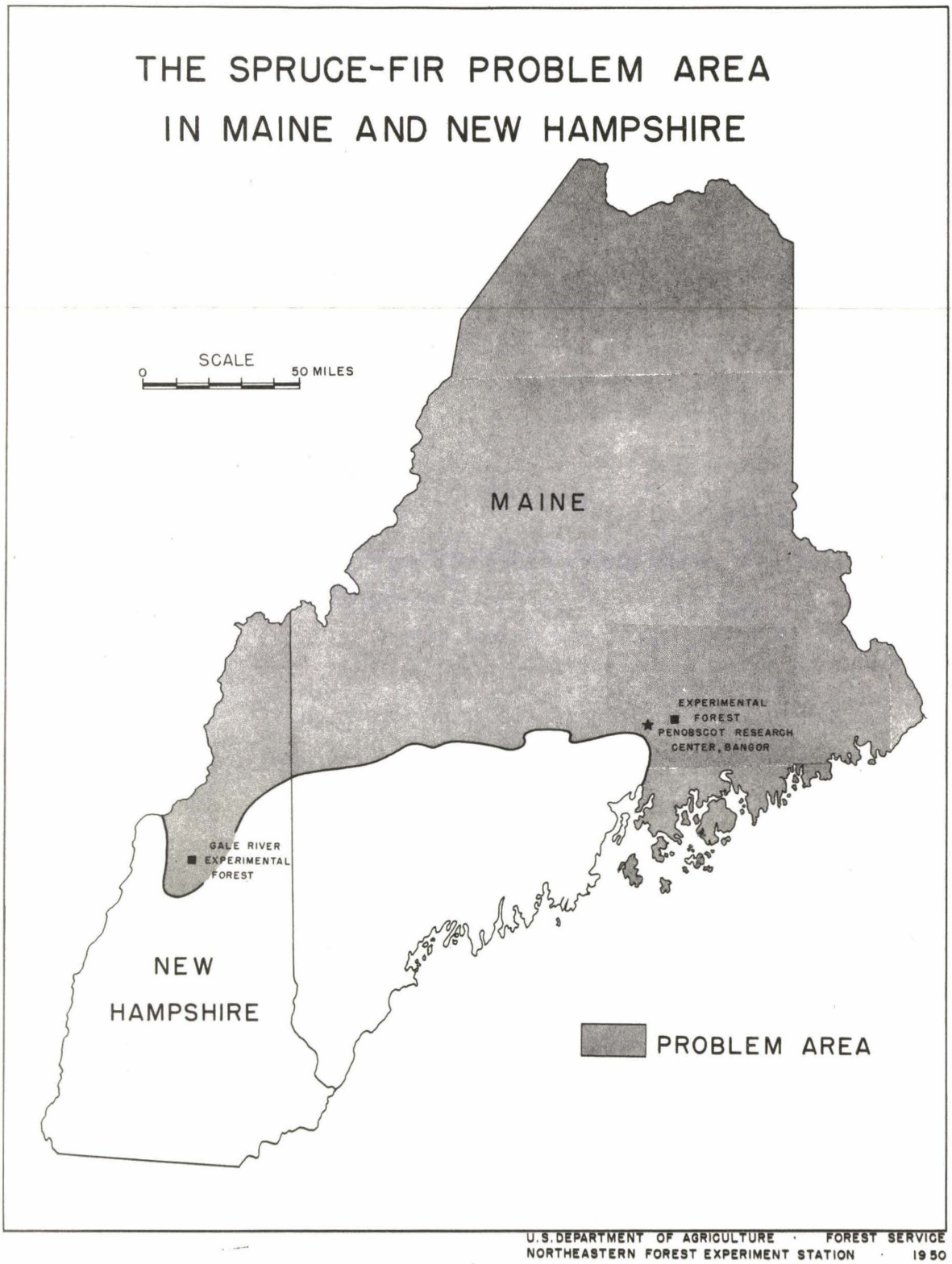
The report is not for publication; rather it is intended for station administrative use and for information of research workers and others vitally interested in the forest-management problems of the spruce-fir area. Its main purpose will be served if it helps to keep the Station's limited forest-management research for that area aimed at solution of the most urgent problems.

V. L. Harper

V. L. Harper
Director

TABLE OF CONTENTS

	Page
INTRODUCTION	1
THE LAND, THE RESOURCES, THE PEOPLE	
This is the forest primeval	3
A poor country for agriculture	5
Water and wildlife—important resources	6
Agriculture and industry	9
Who owns the forest?	11
Our capital stock: investments...	15
...Minus depletions...	17
...Plus interest	20
A LOOK BACKWARD	22
Clear cutting vs. partial cutting	24
Cultural measures—investments in the future	25
Some advance reproduction is generally present	26
Logging slash—what to do with it?	28
REGIONAL PROBLEMS—ABOVE AND BEYOND SILVICULTURE	
After Canadian labor—what?	29
Hardwoods don't float	30
The big problem—as always—is transportation	31
The theory of stumpage reserve	31
The paradox of the small ownership	32
REGIONAL PROBLEMS—GETTING BACK TO THE WOODS	34
First things first—cutting practices in operable stands	34
Tomorrow's pulpwood—the inoperable stands	36
The long pull—rehabilitation of non-restocking areas	37
And now, to cure the ailment...	38
...What is the treatment?	39
And will it be worth the cost?	41
Some other problems need attention	42
THE RESEARCH PROGRAM TO BE UNDERTAKEN DURING THE NEXT FIVE YEARS	48
CONCLUSION	
The final problem—research into practice	56
LITERATURE CITED	57
APPENDIX	61


THE SPRUCE-FIR PROBLEM AREA
IN MAINE AND NEW HAMPSHIRE
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HAMPSHIRE
PROBLEM AREA
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Figure 1

PROBLEM ANALYSIS FOR FOREST-MANAGEMENT STUDIES: SPRUCE-FIR (AND ASSOCIATED HARDWOODS) REGION OF MAINE AND NEW HAMPSHIRE[1]

by Thomas F. McLintock[2]

October 1950

INTRODUCTION

IT IS SIGNIFICANT that the theme of the 70th annual convention of the American Paper and Pulp Association held in 1947 in New York was the seriousness of the steadily decreasing supply of raw materials. R. B. Roberston, president of the APPA, said in his keynote address, "The Nation will not be well served, and we will not fully satisfy our obligations, if the industry fails to supply public needs now and in the future because of short sightedness in the matter of supply of essential materials for the long time outlook." He then went on to say that wise use of our forests demands treatment of timber as a crop rather than as a mineral to be mined.

This is a healthy attitude on the part of an industry which, in Maine, is the biggest producer and user of wood. Prompted as it is by a fear of raw-material shortage, it is likely to sharpen and intensify in the coming decade.

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[1]Prepared in 1948, revised in 1950. [2]Forester, Northeastern Forest Experiment Station; in charge of the Station's Penobscot Research Center, Bangor, Maine.

Insofar as the spruce-fir region of Maine and New Hampshire is concerned, the situation is somewhat different than in other parts of the country where pulp and paper companies draw their wood supplies. The land-ownership pattern is different; we have vast areas of remote timber which at present are often operated in huge units of one or two townships or more, which means that immature timber is either harvested along with the mature timber, or—if it is passed by—much of it is permitted to attain maturity, develop rot, and die or blow over before another operation is feasible. Then too, of the dozen or more species that occur naturally and in varying degrees of abundance, only spruce and fir are universally acceptable for pulpwood. Hemlock can be used by some plants, hardwoods by a few. The result is that only part of the productive capacity of most stands is ever utilized.

"Reappraisal" statistics[3] show that in Maine the annual growth of spruce and fir (1,300,000 cords) is exceeding the annual cut (1,080,000 cords). By itself this seems like a rather favorable balance, but the 200,000 cords surplus of growth over drain could not satisfy all our requirements if the Canadian supply were shut off. Pulpwood consumption has been going up and is expected to continue in that direction for at least the next 5 years. Then too, if the spruce budworm epidemic again surges through the spruce-fir region of Maine we may lose 15 million of our 38 million cords of total spruce and fir growing stock. It all adds up to a definite need for increasing the wood production on our spruce-fir lands.

There is now the start of a discernible trend on the part of the industrial landowners to improve their operational practices. Little by little they are beginning to request technical information, advice, and assistance. It may be only a little while to the time when these few requests will suddenly have grown to a clamorous demand for answers to problems of forest management. We must be able to say not only "This is how you do it," but also "This is about what we think it should cost in terms of labor expenditure, use of equipment and other woods operation investment," and "This is the additional volume and value of wood that you should get."

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[3]Estimates by the Forest Service in 1945; compiled from available sources. The National Forest Survey has not reached Maine except in Hancock County, which was surveyed in 1946.

THE LAND, THE RESOURCES, THE PEOPLE

THIS IS THE FOREST PRIMEVAL

"MAINE," REMARKS TOYNBEE, the contemporary historian, "survives today as a kind of museum piece—a relic of seventeenth-century New England inhabited by woodmen and watermen and hunters." As applied to the spruce-fir region of the State, this appraisal, unflattering though it may be, comes very close to the truth. In western Aroostook and northern Piscataquis Counties there are more than 7,500 square miles of unbroken forest, without a road—except for a few private ones built and maintained by paper companies—and with scarcely a score of permanent buildings housing year-round occupants. The area in and around the Grand Lake Stream Purchase Unit in Washington and Hancock Counties covers another 2,000 square miles of the same kind of country. And there are others in northern Franklin and Somerset Counties and west of the Houlton-Presque Isle highway in Aroostook, each of more than 1,000 square miles in extent.

This vast and unpopulated wilderness constitutes much of the territory and contains most of the problems dealt with by the Northeastern Station's Penobscot Research Center. The spruce-fir problem area in Maine[4] comprises all of the State east of the Penobscot River, and that portion west of the river lying north of U. S. Highway 2. It takes in Aroostook, Hancock, Washington, Piscataquis, Franklin and Somerset Counties, practically all of Penobscot and half of Oxford Counties.

With a directness typical of the State-of Mainer's matter-of-fact approach to nearly everything, the unsettled portion of this area is commonly, and semi-officially, called simply "the wild lands". A more appropriate term can hardly be imagined, for remoteness and virtual inaccessibility, which are implicit in the phrase, are the major geographic, social, and economic forces in the region. Here indeed is a land inhabited by woodmen and watermen and hunters.

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[4]Although the discussion here and following is concerned primarily with Maine, the problems represented are also typical of northern New Hampshire. See map (fig. 1) for outline of the spruce-fir problem area.

In the first annual report of the Forest Commissioner of Maine in 1891, it was estimated that 12 million acres of the State were in forest. Land development for agriculture was still proceeding and reached its peak in the early 1900's. Settlers soon found that little of the cleared land was really suitable for crops and the tide began to recede. The withdrawal was especially pronounced around the fringe of the great timbered areas, and the forest gradually reclaimed its own. By 1920 timbered acreage was back up to 15 million acres, and still the retreat continued. Even today records indicate that 10,000 acres of farm land are being abandoned yearly, while the amount of land cleared is negligible.

Most recent land classification figures show the following picture for the State as a whole.

Class	Acres
Forest land*	16,788,000
Crop land**	1,417,000
Other farm land**	747,000
Barren land*	711,000
Inland water***	1,392,000
Other nonforest	203,000
Total***	21,258,000

*Federal Reserve Bank of Boston. Wooden Dollars. 1949.

**U.S. Bureau of Census. Census of Agriculture. 1945.

***U.S. Bureau of Census. 16th Census of the United States. 1942.

The gross area of the spruce-fir region in Maine is approximately 15½ million acres, and within it reside some 330,000 persons. Thus, 75 percent of the State carries less than 40 percent of the population. As can be seen in table 1 (appendix), Aroostook and Penobscot Counties account for 60 percent of the population in the spruce-fir region of the State, which is largely explainable on the basis of the only two centers of population in the region that remotely justify the term: the "Bangor-Brewer-Old Town" and "Houlton-Presque Isle-Caribou" areas.

The territory is probably the most sparsely populated area of its size east of the Mississippi. There is no city with a population of more than 10,000 (except Bangor, which properly speaking does not lie within the spruce-fir region but is the gateway to it), and only seven of more than 5,000. By far the greater proportion of the people live in rural areas. Yet, the dispersal of the population is far from uniform, for probably 90 percent of the people actually live on 10 percent of the land. Villages lie loosely connected along the principal highways, and smaller settlements huddle at wider intervals along secondary roads, often separated by an almost unbroken expanse of forest. Because of the fire danger which accompanies the opening-up of timberlands to the public, it has been undesirable for the large timberland owners to attempt a wholesale "colonization". Furthermore, such a venture would have been economically impractical. Since water transportation of wood plus winter hauling by sled has made permanent road systems unnecessary so far, the wild lands have remained, largely a wilderness, unsettled and unimproved, flanked by frontier conditions similar to those of pioneer days.

A POOR COUNTRY FOR AGRICULTURE

The climate of the region is cool and humid throughout spring, summer, and fall. There are few unpleasantly hot days, and though the humidity is often uncomfortably high, nights are cool even in July and August. The annual precipitation averages between 35 and 40 inches and is nearly always well distributed throughout the growing season. Even in 1948, an exceptionally dry year, rainfall for the 4-month period from June through September averaged more than 7 inches.

A short average growing season of little over 3 months limits the number of crops that can be safely and successfully grown. Late spring and early fall frosts often cause considerable damage to orchards and small fruits. Slowness of soil to thaw on sheltered locations also represents a distinct handicap to farmers.

Average annual snowfall, from 70 to 130 inches, increases with distance from the coast. It is not uncommon to have an accumulation of 4 or 5 feet in the northern part of the State, while in southern Hancock and Washington Counties there may be scarcely a foot. Snow is usually gone and the

lakes free of ice by the middle of April in the lower end of the region, whereas it is usually a month later before this occurs north of Moosehead Lake.

Storms are likely to be violent, but are usually of short duration. Wind causes considerable damage to timber in these short, often localized storms, and must always be given careful consideration when partial cuttings are contemplated.

Most of the spruce-fir problem area has been classified by the Department of Agriculture as "not suited to cultivation because of poor drainage, stoniness, extremely low fertility, extreme erosion hazard, steepness of slope, or other factors." Since relatively few areas are of agricultural importance, little is yet known of the characteristics of the principal soil types. Derived chiefly from glacial deposits, the soil is extremely varied; and it is characterized by abrupt changes in texture, drainage, and fertility. Shallowness, with scattered boulders and frequent rock outcrops, is its most consistent characteristic.

Over the entire region are found series of eskers or kames, known locally as "hoss-backs", which extend from 1 to 150 miles in length. These ridges of gravel and glacial debris, deposited by the receding glaciers of the Ice Age, supply most of the region's road material and often are the best possible road building sites.

Physiographically the spruce-fir region can be divided into a coastal slope province and a plateau that is an extension of the New England uplands. The coastal slope rises in an inclined plane northward and westward from the coast, producing an irregular topography characterized by many hills, valleys, ponds, and lakes. A line running from the southwest corner of the region northeast to Mt. Katahdin and thence north to the St. John River marks the approximate termination of the coastal slope.

WATER AND WILDLIFE--IMPORTANT RESOURCES

Water is one of the great natural resources of the region. Floods are not so frequent as in many other watersheds in New England. But flood damages have been severe, particularly in the coastal area where industry and population is concentrated.

Of electric power generated in Maine, 68 percent is hydro-electric.[5] The installed capacity of developed water-power sites in Maine in 1941 totaled 637,000 horsepower. Potential water power available 90 percent of the time is rated at 524,000 horsepower, and available 50 percent of the time at 806,000 horsepower. A sustained yield of water is of vital importance to the industrial life of the State. This is particularly true because Maine has no resources of coal or oil or other dependable fuel; these can be obtained only at a high cost for transportation.

The unbroken wilderness area that covers all of the important watersheds and the hundreds of lakes and ponds have contributed to a dependable flow of water. However, during drought periods serious deficiencies have occurred. Only a few years ago an aircraft carrier had to be rushed to Portland to supply that city with electric power.

It should be constantly borne in mind that the methods by which we manage the forest stands in these watersheds are going to affect the water resource. In the long run destructive logging and fires will lead to more frequent floods and longer and more critical periods of low water.

Although declining in importance with the advent of improved roads and truck transportation, waterways have long been one of the principal means of moving wood to the mills. The principal rivers in the region (fig. 2) are the St. John (211 miles in length from its source in St. John Pond to the State boundary), St. Croix (75 miles), Penobscot (350 miles), Kennebec (150 miles), and Androscoggin (175 miles).

The more than a million acres of lakes and ponds, which constitute both the basis for power development and major transportation arteries for pulpwood and logs, also represent a highly valuable recreational resource. The recreation business is a highly organized enterprise that has a profound effect upon the economics and way of life of the entire State. In 1949, according to the Maine Development Commission, it brought $125,000,000 in trade to resorts, filling stations, restaurants, sporting goods establishments, and other businesses catering to the needs of the tourist and sportsman. The assessed value of recreational property in 1930 was $53,766,000

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[5] Source: Edison Electric Institute. 1949.

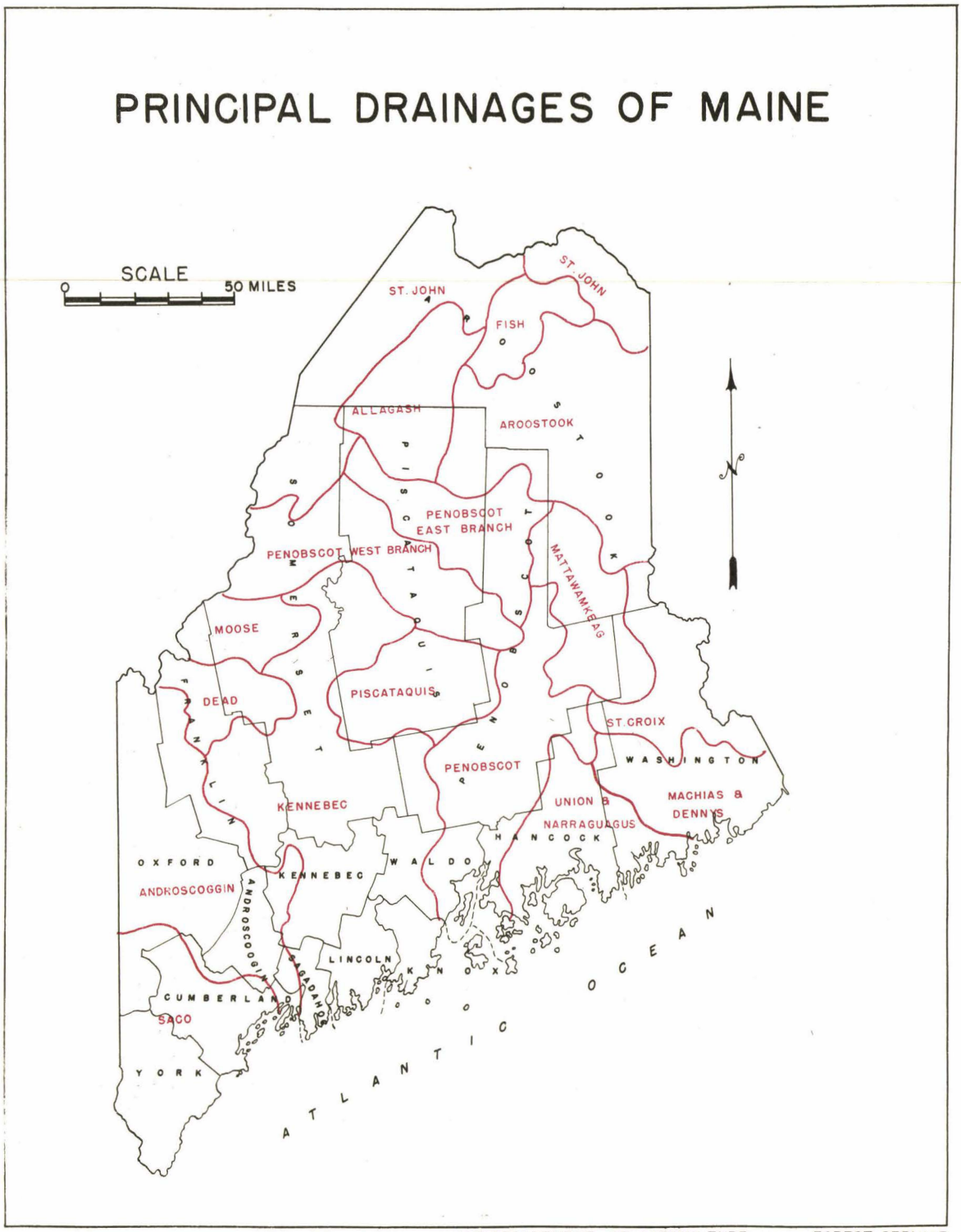

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Figure 2

and more than 23,500 persons, earning more than $7 million in wages, were employed in this "industry". Non-resident hunting and fishing licenses bring the State more than $100,000 annually.

Like the lakes and ponds, the forest is a basic resource upon which the recreation business depends. It provides scenic beauty for the nomadic tourist; it supports deer and grouse for the hunter; it controls water levels in lake and stream for the fisherman. But the relative inaccessibility of the wild lands, discouraging wholesale invasion by swarms of pleasure-seekers, has been highly effective in preventing many serious forest fires.

AGRICULTURE AND INDUSTRY

As has been previously stated, this is not an agricultural region. To be sure, the potato is in a class by itself; it is not just a vegetable,it is an "institution". Aroostook County accounts for 82 percent of the State potato production, which in 1943 reached the amazing total of 73,485,000 bushels. The poultry and dairy industries are concentrated in the southwestern part of the State. These enterprises are small, but important locally, and their proximity to eastern markets places them in a strategic position. Except for the blueberry business, which dominates the coastal area in Hancock and Washington Counties, and of course potatoes, agricultural activities within the spruce-fir region are the same as those that find their best development in the adjoining white pine region.

Farms average 109.4 acres, including woodland, according to the Census of Agriculture. Area in crops averages about 60 acres per farm in Aroostook as against only 25 acres per farm for the rest of the region. The following listing of agricultural products and their values was taken from the 1945 Census of Agriculture, and represents reports from more than 40,000 farms. Further agricultural statistics are shown in table 2 (appendix).

Product	Value of products sold
Field crops	$ 51,008,368
Dairy products	17,142,920
Poultry and poultry products	13,589,164
Livestock and livestock products	4,895,087
Forest products (farm woodlots only)	4,184,459
Vegetables	2,872,482
Fruits	2,622,667
Horticultural specialties	1,600,493
Total	$ 97,915,640

The primary wood-using industry is the largest in the State in value of product and payroll (table 3, appendix). It would also be the largest in number of employees if part-time woods workers were counted. The State's more than 800 active wood-using plants that make up the industry are located principally in small towns with populations between 2,000 and 5,000. Distribution of these plants by counties is shown for the region in table 4 (appendix).

Tables 5 and 6 (appendix) show, for the spruce-fir region, numbers of persons employed in the principal industries according to the 1940 Census. Although only 5,000 persons are listed as employed in logging, this is known to be considerably less than the total labor force required each year. At least half of the logging labor is imported from Canada. This bonded labor force is the backbone of the region's pulpwood-producing industry.

The pulp and paper industry is the most important one in the State. Its contribution to the State's economy comes not only from the mill payroll and value of finished product, but also from the fact that it draws its raw materials largely from within the State. Annual pulpwood consumption has climbed from 342,000 cords in 1899 to nearly 1½ million cords in 1948, 75 percent of which originated from Maine timberlands. In 1946 Maine was second only to Washington in woodpulp production. The daily rated paper mill capacity of 3,800 tons makes Maine one of the three or four highest producers of paper in the country. Diversity of manufactured

articles by individual companies is an important feature of the industry, which has, with the exception of newsprint plants, little of the specialization typical of southern mills.

Assuming adequate wood supplies, the future prosperity of the industry seems assured in Maine. To be sure, production from the young and aggressive southern mills is still on the increase, but these two segments of the industry are not in direct competition for the same markets to any great extent. New England paper products have a quality that southern mills so far cannot economically duplicate with their darker and more pitchy woods. The average yields from spruce and fir are also somewhat higher than from southern pines, partly because of the adaptability of the northern species to the groundwood process. Proximity to Boston, New York, and Philadelphia markets also places the industry at a competitive advantage.

There is, however, some question as to the possible extent of future expansion. Recent enlargements of mill facilities have been relatively minor and have been largely a co-result of modernization of machinery. One exception has been the construction of new sulphate mills, one at Rumford and the other just over the line in New Hampshire. Both of these were additions to existing plants and both were built primarily to take advantage of the readily available hardwoods. To some extent the added new capacity supplants some of the former sulphite capacity. For the present, at least, large-scale expansion is out of the question because of the difficulty of obtaining enough wood. With the prospects for better forest management, and an increase in forest productivity, a substantial balance of growth over drain may eventually bring about the need for added mill capacity. If more wood brings with it lower operating costs, however, the first result will probably be a reduction in Canadian pulpwood imports.

WHO OWNS THE FOREST?

To a large extent, the development--or lack of development--of the forest resource in the spruce-fir region of Maine is a reflection of the land-ownership pattern, the outstanding features of which are:

- The size of individual ownerships. It is estimated, for example, that 10 companies own more than $6\frac{1}{2}$ of the $13\frac{1}{2}$ million acres of forest land.

- The extensive holdings of non-operating landowners.
- The "common and undivided ownership" with its peculiar legal and management implications.
- The insignificant amount of publicly owned forest.

No published figures are available showing distribution of forest-land ownership in the spruce-fir region of Maine by classes of owners. The following tabulation has been assembled largely from the Maine State Valuation Report for 1948.

Type of owner	Acres
Pulp and paper companies	5,700,000
Lumber companies	100,000
Non-operating owners:	
Farmers	1,100,000
Other small holdings*	2,300,000
Medium holdings**	1,000,000
Large holdings***	3,300,000
Total	13,500,000

*Less than 500 acres in a single ownership.

**Less than 10,000 acres in a single ownership.

***Individual ownerships in excess of 10,000 acres.

The last two groups are largely land companies, realty companies, banks, estates, investment groups, and defunct lumber companies.

The development of the current pattern of timberland ownership in this region arose from a long series of grants to and purchases by schools, colleges, individuals, and land companies. Many of them were made before Maine separated

from Massachusetts in 1820 and became a state in its own right. The lands were in many cases sold and resold, especially during the period of wild land speculation between 1830 and 1835. Once the ownership had stabilized, a great deal of timberland was handed down to and held in trust for heirs of the original owners.

The development of land ownership by pulp and paper companies is of more recent origin, and does not seem to have come about in any particular pattern. It started toward the end of the last century and gained momentum around the early 1900's. One company, for example, held 260,000 acres in 1899. By 1916, it owned a million acres, and its holdings now run well over two million acres and are still slowly increasing. Similarly, other companies having large plant investments have sought to protect those investments by purchasing extensive areas of pulpwood-producing land.

It is not now, and probably never was, the intention of the paper companies to obtain their entire wood requirement from their own holdings. A balance was desired between their own wood and purchased stumpage, both of which they operated themselves, and purchased wood--mostly from farmers and other small landowners. It has consistently cost more to produce wood through their own operations, because of the relative economic inaccessibility of their holdings and of those from whom they bought stumpage, than to buy wood from the small producer whose tract of timber was easily accessible and who had little or no investment in camps, roads, stream improvements, and equipment. When open-market wood is scarce or abnormally high-priced, companies increase the scale of their own operations, which often has the effect of depressing the price of open-market pulpwood. During periods of low pulpwood prices the consuming companies turn to the open market for the bulk of their wood supply. The land-management policy of these companies is still to maintain, and occasionally add to, their holdings.

The large non-wood-using owners are holding their timber as an investment, or in trust for heirs of various estates. The largest of this class of owners has holdings in excess of a million acres. Since the decline of the lumber industry, their principal source of income is derived from the sale of stumpage to the pulp and paper industry, now the only important market for spruce and fir. Hence, over a large part of the region they are dependent upon the advance of company operations into the remote areas where most of the larger holdings lie. Their lands commonly are in scattered large

blocks--often averaging 10,000 acres or more--well enough distributed over the region and spotted among holdings of the operating companies that they have so far been able to make frequent stumpage sales, and show fairly continuous returns over expenses.

A very interesting aspect of the land-ownership pattern more typical of, but not peculiar to the estates and land companies, is the so-called undivided ownership. When a timberland owner died, his timberlands would usually be willed to his heirs, but seldom was the tract divided with specific portions of it allotted to any individual son or daughter; the ownership was undivided. This process continued from one generation to another, the numbers of part owners increasing in geometrical progression. Further complicating the picture were frequent sales and re-sales of fractional portions of a township or other tract by one or more heirs. The result is the present hodge-podge of ownership, in many cases running into such fantastic fractional parts as 23/13,820ths. These partial ownerships are still undivided--with each owner having legitimate claim to his fractional part of every acre--or every tree--in the township.

This complicated ownership pattern naturally presented problems in bookkeeping, management, and litigation; as a result land companies were formed to take care of the combined interests of groups of heirs. Unfortunately with but few exceptions, the people selected to manage the timberlands were not foresters, or even acquainted with the woods, but were lawyers, retired judges, real estate agents, or some one of the heirs themselves who felt that a college education was all that was necessary to administer a hundred thousand acres of timberland.

At the present time, there is a distinct trend in ownership <u>from</u> the estates and land companies <u>toward</u> the pulp and paper companies. This trend is compounded of a willingness on the part of some of the heirs and estate trustees to liquidate uncertain and unprofitable holdings, and anxiety on the part of the paper companies over future wood supplies. But whether control of the wild lands lies in the hands of paper companies, land companies, or heirs of Maine's early timber barons, the broad management objective is the same: to insure a sustained productivity. The mandate to provide owners with a periodic income and mills with a continual supply of wood provides a powerful leverage upon those who manage the land. Thus it is that in nearly 10 million acres of the spruce-fir region lies the promise of continuity of ownership that can and

should encourage improved forest management, as rapidly as economic conditions, technical know-how, and the timberland owners' will-to-do permit.

OUR CAPITAL STOCK: INVESTMENTS...

Dominating the forests of the region are some 11 million acres of spruce-fir and associated types in which these two species are the ones of major importance. Principal subordinate species are hemlock, yellow birch, beech, paper birch, and red and sugar maple. An additional 2½ million acres of hardwood lie in extensive tracts throughout the spruce-fir region with principal concentrations in the middle and upper Androscoggin, Kennebec, and Penobscot drainages. These stands, chiefly beech, birch, and maple, have been deteriorating badly for the last decade, and are being slowly replaced by inferior hardwoods or, on middle and lower slopes, by spruce and fir.

The domain of white pine has shrunk to about 3 million acres, mostly in the coastal belt lying in the Saco and lower Androscoggin, Kennebec, and Penobscot drainages. Though it still occurs in scattered operable quantities all over the State, it is here that the last extensive tracts of second-growth pine are concentrated.

The six principal spruce types found in the region are the yellow birch-red spruce, red spruce-sugar maple-beech, paper birch-red spruce-balsam fir, black spruce, red spruce, and balsam fir types.[6] The stands themselves vary greatly in composition, ranging from pure spruce and fir stands commonly encountered in the spruce slope, spruce swamp, and old-field spruce associations, to considerable admixture of northern hardwoods frequently observed on benches, lower mountain slopes, and low ridges. The quality of hardwoods in the spruce types depends chiefly upon the character of the soil and the drainage. On relatively shallow and poorly drained soils characteristic of the spruce slope, spruce swamp, and portions of the spruce flat types, hardwoods show poor development and are subject to considerable defect. On the other hand, in the yellow birch-red spruce and red spruce-sugar

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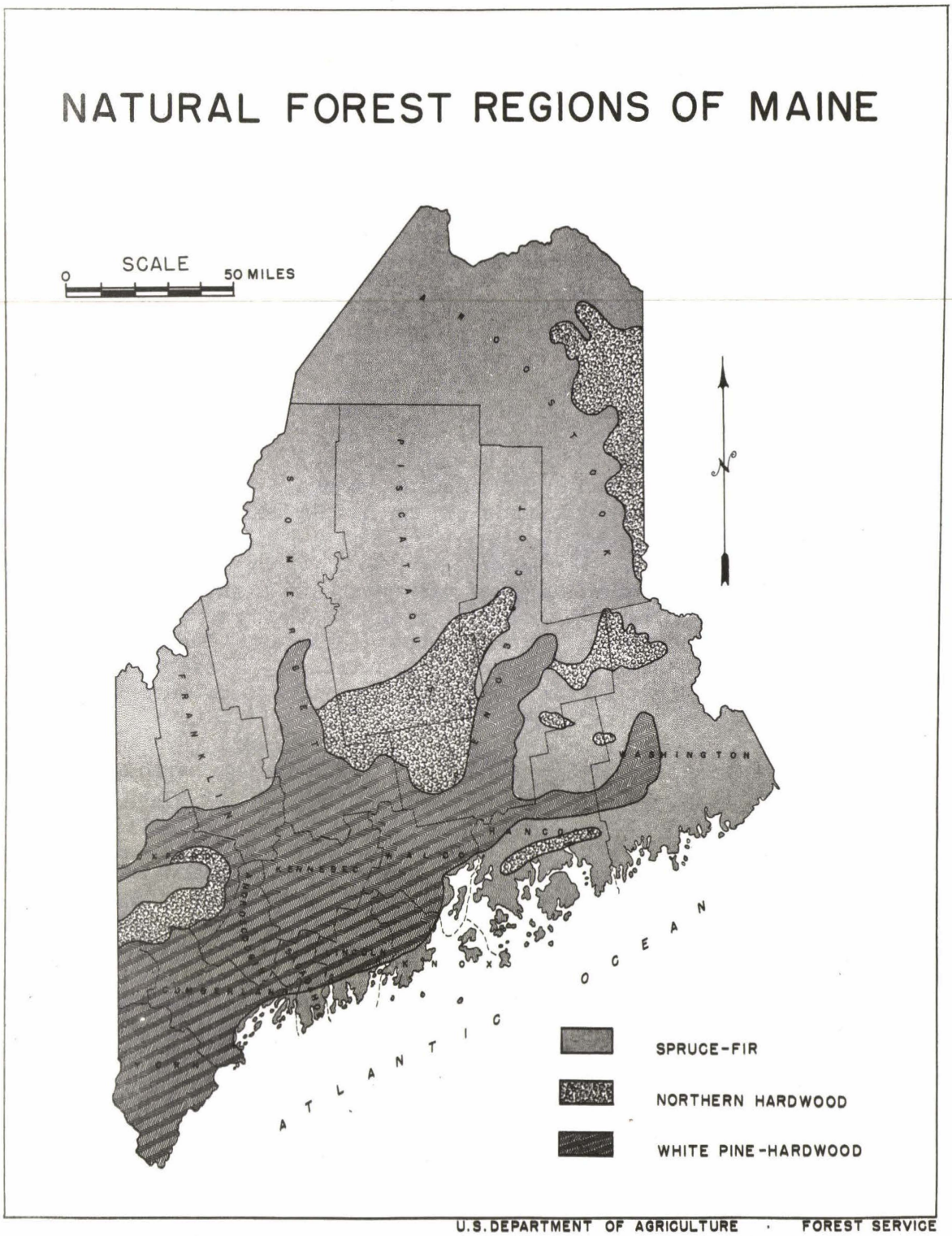
[6] As defined by the Society of American Foresters in Jour. Forestry 30: 451-498. April 1932.


NATURAL FOREST REGIONS OF MAINE
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WHITE PINE-HARDWOOD
ATLANTIC OCEAN
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Figure 3

maple-beech types, which have soil of fair depth and fertility, northern hardwoods attain good form and size.

By far the greater part (99 percent) of the 13.5 million acres of forest in the spruce-fir region of Maine is second growth. Logging of one kind or another has pretty well covered the region and practically no virgin timber is left. There are an estimated 135,000 acres of hardwoods and 25,000 acres of spruce which have never been touched, but these are insignificant in the total picture. However, much of the second growth represents areas cut for sawlogs 50 or more years ago, when considerable volumes of small trees below 12 inches d.b.h. were left, with no cutting since. This type of timber is commonly referred to as "old growth".

The approximate acreages of operable stands and of those lacking operable amounts of merchantable sizes are as follows:[7]

Item	Operable	Not operable
	Acres	Acres
Spruce-fir	4,161,100	6,968,500
Hardwoods	1,734,200	902,400

Volumes have declined rapidly since 1910, when it was estimated that there were more than 70 million cords of spruce and fir in the State. Current estimates place the volume of spruce and fir at slightly less than 38 million cords, of which 10.7 million are considered unoperable. The estimates which are shown in table 7 (appendix) are for the entire State; no breakdown is available for the spruce-fir region alone.

...MINUS DEPLETIONS...

The Maine Forest Service reports that lumber production for the entire State in 1949 was 537 million board feet, 60 percent of which was pine. Most of the timber cut in the

[7]From an unpublished report on Timberland Pulpwood Resources of Maine, prepared for the Maine State Bureau of Taxation by James W. Sewall in 1944.

spruce-fir region is converted to pulpwood and about 85 percent of the 1¼ million cords cut in 1949 came from there. The total operating drain for 1949 by species and class of product is given in table 8 (appendix).

In addition to commodity drain there is a serious annual depletion of our timber resource due to fire, insects, disease, and wind. In common with the rest of northern New England, Maine has come to be called the "asbestos belt" because of the relatively light damage from fire. Ten-year average annual loss from 1934 to 1945 has been estimated at about 2½ million cubic feet, which on a percentage basis is rather low. In 1946, according to the Maine Forest Commissioner's report, there were 576 fires, which burned a total of 10,327 acres, causing damage estimated at $95,932. Prior to 1947, the worst year since 1936 was 1941, when 481 fires burned over 40,350 acres at a loss of $511,340. Most of the facts and figures pertaining to the 1947 conflagrations are now common knowledge. The greatest damage occurred in the white pine region, but four extensive fires on Mt. Desert Island, and near Jonesboro, Cherryfield, and Madison burned over nearly 38,000 acres. The extremely high fire hazard, plus inefficient fire-protection organization on the part of town[8] fire crews, were largely responsible for the widespread damage. In the wild lands, however, an efficient State fire-protection organization plus good rainfall distribution and short fire season have usually combined to keep fire fairly well under control.

Insects and disease are another matter entirely. The forests of the region seem unusually vulnerable to attack by a great variety of destructive pests. The most serious enemy of the softwoods (not counting pine) has been the spruce budworm, now threatening another invasion. A few years ago the spruce was menaced by the sawfly, and the spruce bark beetle causes considerable damage. Most of the eastern larch was cleaned out by a widespread infestation of the larch sawfly in the late nineteenth century. This species, once an important component of many softwood stands on moist sites, is just beginning to regain its former position. The balsam wooly aphid has been increasing in importance yearly. Not so long ago its damage was confined to a relatively narrow

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[8] Generally called "township" in other regions, but "town" in New England.

coastal strip, but in the last few years it has been gradually working inland. It is probably the most serious insect pest on the Penobscot Experimental Forest at the present time. Trunk and butt rots destroy uncounted thousands of cords of balsam fir yearly, and red ring-rot takes its toll of spruce.

Probably the most spectacular and widespread damage evident in the region is the dying of yellow and white birch. There is considerable disagreement among entomologists as to just where the insect enters the picture. Some insist that the bronzed birch borer is a primary cause of this mortality, while others maintain its action is strictly secondary. The State entomologist estimates that 75 percent of the birch in the State is dead or dying, although in 1949 and 1950 considerable improvement in the condition of the white birch was noted. The beech has suffered heavily in relatively recent years from the beech scale, which seems to be progressing westward. This insect, and the nectria canker which follows it, threatens eventually to wipe out the beech in the Northeast. Maple also is subject to damage by a nectria canker as well as by the sugar maple borer.

The average depletion of timber in the State as a whole from insects and diseases has been estimated at close to 80 million cubic feet a year. A breakdown of this total, by softwoods and hardwoods and by size of timber, is tabulated below.

Item	All timber	Sawtimber trees	Pole sized trees
	M cu.ft.	M bd.ft.	Cords
Softwoods	13,898	13,900	130,800
Hardwoods	65,600	154,000	288,027
Total	79,498	167,900	418,827

The seriousness of this depletion is magnified by the increasing exposure of residual, unattacked trees, especially birch, following the heavy mortality in the surrounding stands. Continued inroads threaten to change completely the ecology of forests in this region, as well as throughout the remainder of northern New England. The total estimated annual depletion from sources other than cutting is close to 82 million cubic feet for Maine, which is 23 percent of the total annual drain of 358 million cubic feet, or 30 percent of the

commodity drain of 276 million cubic feet. In other words, for every thousand feet of timber cut for use, there is an additional 300 feet lost through insects, disease, fire, wind, or other agency. Of this 300-cubic-foot loss, only 9 cubic feet represent fire loss; most of the remainder is due to insects and diseases.

...PLUS INTEREST

Let us assume an average annual drain in the spruce-fir region of 1½ million cords of softwoods, and 1 million cords of hardwoods. To what extent is this volume being replaced by growth?

Most of the hardwood stands in the region are mature or overmature, and as such represent low-earning capital. Natural decadence had already set in to a considerable extent when the birch borer and the beech scale developed in epidemic porportions. It seems inevitable that the mature saw-timber stands will have to be largely written off as a loss. Even now most operations for beech and yellow birch have the depressing appearance of salvage jobs. The result is that the total drain in hardwood saw timber greatly exceeds growth even without any cutting. Annual increment in pole-sized hardwoods is somewhat more encouraging, and actually exceeds the drain. It is hoped that these younger and thriftier stands will be more disease- and insect-resistant, and under improved forest management will constitute a growing and continuing asset.

There is practically no virgin timber left in the spruce-fir types, and the present saw-timber stands are largely residual stock from long-log cuttings made 30 or 40 years ago or longer when a 10- or 12-inch diameter limit was observed. Such stands, loosely classified as "old growth", now cover nearly 6 million acres in the spruce-fir region. On much of this land the net merchantable volume remains almost static. When it is remembered that little fir was cut in the long-log days and that spruce smaller than 12 inches d.b.h. was usually left standing, it takes little imagination to picture the present condition of a forest logged in 1900 and not cut in since. The hold-over spruce has reached or is approaching maturity and has passed its peak of growth. The fir is mostly overmature, decadent and heavily infected with rot. Only the growth of the younger pole-sized trees—usually well distributed through the forest—prevents a

widespread decrement over several million acres.

To be sure, this static condition does not apply to all the saw-timber stands. Most of the areas cut for logs since 1920 support a vigorous growing stock with annual increment close to 0.6 cord per acre on the best sites, and averaging probably 0.3 cord.

Since the advent of "4-foot wood" and the resultant heavy cutting by the pulp and paper industry, probably 5 million acres have been cut to a 6- or 7-inch diameter. On probably half of this acreage there is no growth at all, inasmuch as brush and weed species have occupied the land where spruce and fir formerly grew. Such areas now contribute nothing to the economy of the region and represent an acute rehabilitation problem. On the remainder of the land cut over for pulpwood in the last 30 years there is a gradually improving residual stock of young softwoods. Growth in such stands varies greatly with site, intensity of past cutting, and present composition. On the best of such areas increment will exceed half a cord per acre yearly, but on the average a fifth of a cord is the best that can be expected without the benefit of management.

For the region as a whole, the best available estimates of growth and drain point to a net annual increment of about 200,000 cords of softwoods. But considering the tremendous noncommodity drain, the gradually declining average tree size, and the general lack of good cutting practices to build up the growing stock, one can only take a rather dismal view of the present growth-drain balance as a whole. The adoption and application of cutting practices aimed only at a reduction of insect and disease losses would more than double the present net growth of spruce and fir. Indications are that under still more intensive management, whereby composition, density, and size-class distribution are closely controlled, an average growth rate of a half-cord per acre per year on all but the poorest sites is not too high a goal to aim for.

A LOOK BACKWARD[9]

THE COURSE OF SAWMILL logging in Maine has followed a more conservative pattern than in other parts of the Nation where a path of devastation followed the operation. There was no lumber industry as such until the early 19th century, and most cutting was for the purpose of clearing land and providing fuel and shelter. As white pine came into its own as an object of international trade the tempo of cutting was stepped up. Operations advanced into what we now consider the spruce-fir region. Here, however, pine stands and trees were intermingled with spruce and hardwoods, and logging left the land in possession of a reasonably good forest cover.

History records that the first spruce was driven down the Kennebec in 1850. Cutting of spruce was recorded on the Mattawamkeag River in 1845 and on the Dead River in 1850. But it was not until after the Civil War that spruce lumbering became widespread, and at the same time pine gradually decreased in importance. By 1880 only 20 percent of the Kennebec drive was pine; the rest was spruce.

With the passage of time the minimum diameter limit dropped sharply. Up to the end of the century the cutting policy was to take only the largest and best pine and spruce for sawlogs. In the spruce-fir region this meant leaving trees 12 inches in diameter and often larger, and a good residual stand remained. With the development of the pulp and paper industry in the early 1900's the diameter limit dropped to 10 inches for pulpwood logs, and later it became common practice to cut everything from 8 inches up. During

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[9] In the discussion which follows, major emphasis will be placed upon the spruce-fir types, with little or, in some cases, no mention of hardwoods. This omission is not due to lack of appreciation of the importance of hardwoods in this region, but primarily to the fact that insufficient time has been available so far for a first-hand study of conditions and problems of the hardwood types. Moreover, the 3½ million acres of more or less pure hardwood types in Maine essentially are a part of the 8 million-acre northern hardwood problem area of New England, which is being tackled separately as a major project of the Station's Northern Hardwood Research Center, with headquarters at Laconia, New Hampshire.

and shortly after the first World War, and resulting partly from wartime demands and partly from the effects of the spruce budworm epidemic, 6-inch spruce came to be considered merchantable for pulpwood and this has been the general rule ever since, and for fir as well. Actually, pulp mill specifications call for a minimum 4-inch top, which means that trees as small as 5 inches d.b.h. are often cut to give two or three bolts.

Common practice, dictated to a considerable extent by economic expediency, has been to log large areas as one continuous operation, extending from 3 or 4 years to an indefinite period. Little or no attempt is made to segregate, out of perhaps 50,000 acres to be operated over a 10-year period, young stands on which cutting should be deferred for 15 or 20 years from those that are definitely mature, any more than individual trees are cut or left on the basis of their maturity. Thus mature timber is often allowed to become overmature, while immature timber is often cut. In both cases the result is not only an immediate waste of material, but there is also an unfavorable after-effect upon the residual stand.

Very little conscious or deliberate forest management has been practiced to date in the region. Early cutting practices happened to be of pretty good grade but they were largely a result of the market, which would not accept small trees. As the diameter limit dropped, successively poorer residual stands resulted. Because spruce and fir advance reproduction was nearly always present the need for the conscious practice of better cutting was not recognized. As heavy demands for pulpwood became prevalent there were occasional attempts by different companies to provide for the future by intentionally leaving small but merchantable-sized trees.

Such attempts were for the most part well-intentioned, but poorly thought out. When some unfortunate or unfavorable incident occurred, such as heavy loss after a severe windstorm, instead of trying to modify the management plan, a company was prone to discard the whole idea and revert to clear-cutting over broad areas. A number of companies are now considering improving their cutting methods, and some are actually doing something about it. Better cutting methods have been stimulated by two major factors: (1) imminence of the spruce budworm epidemic, and (2) growing concern, previously mentioned, of the pulp and paper industry over rapidly disappearing raw material supplies. As a result, serious consideration is being given to higher diameter limits, more

yarding of tree-length logs and less stump-cutting (cutting into pulpwood lengths at the stump), and setting up operating schedules on the basis of timber maturity.

At present there are only four companies within the reach of hardwoods of the region that use hardwoods for pulp. Economic inaccessibility and lack of transportation systems for hauling hardwood logs have prevented the development of an adequate market for the tremendous hardwood resource lying intermingled with the spruce and fir in the wild-land area of the State. Now, however, with the realization that if the beech and birch is not used soon it will all be lost, several companies are looking for ways to utilize hardwoods. One of the largest of the paper companies is considering a $5-million mill investment to permit paper production from hardwoods. Utilization of hardwoods on a large scale, however, will have to await the development of more extensive road systems.

As better forest-management policies are considered and adopted by landowners, the demand upon the Station for technical information on silvicultural and financial aspects of forest management will steadily increase. Future investigations should be planned with this in mind, and as no research program can be intelligently organized without an inventory of past work and present knowledge, such a summary will serve the dual purpose of cataloging ready-to-distribute research information, and of establishing a level of technical knowledge from which to start further studies.

CLEAR CUTTING vs. PARTIAL CUTTING

As far back as 1891 the first Forest Commissioner's report for Maine stressed the importance of conservative cutting practices. Considerable space was devoted to discussion of such topics as "Economical cutting of our forests", "Depreciation of our forest growth and its effect upon our various industries", and "Relation and importance of our forests to summer tourists, sportsmen, etc." The theme throughout was a warning against too-severe "lumbering" that would strip the forests and leave them unfit for harvests for many decades. Nothing specific was suggested as an improvement, but the keynote was sounded. In his treatise on red spruce Murphy (8)[10] pointed out that clear-cutting was not good

[10]Underlined numbers in parentheses refer to Literature Cited, p. 57.

silviculture except on pure, even-aged, mature stands of spruce and fir where there was a satisfactory stocking of advance reproduction. He recommended selection cutting in uneven-aged stands, or group-wise cuttings in the swamp type or other sites where possible windthrow made selection cutting inadvisable.

On the basis of present knowledge the selection system of cutting is recommended within the limits advisable or permitted by: (a) presence of advance reproduction; (b) age and condition of stand; (c) probable windfirmness of any residual stand which might be left. Under clear-cutting there is heavy damage to reproduction and a period of at least 40, and probably 70 to 80, years must elapse before the same area can be cut again. During this intervening period a considerable percentage of the faster-growing balsam fir in the spruce-fir stands, which is just under merchantable size, usually matures and becomes defective. Westveld estimated such losses on a 60-year-cycle to aggregate as much as 6 cords per acre.

CULTURAL MEASURES—INVESTMENTS IN THE FUTURE

Westveld (13) found that following logging on spruce-hardwood sites, cutting of young hardwoods was highly effective in releasing spruce and fir advance reproduction that had not become well-established or was in danger of being crowded out by the more vigorous hardwood saplings. Also, where there was no advance reproduction and undesirable hardwoods sprang up simultaneously with softwoods, the hardwoods soon out-stripped the slower-growing spruce and fir. Westveld found weeding between 5 and 8 years after cutting to be most effective. During this period machetes and hand axes can be used, making the operation less expensive than when the hardwoods get a little larger.

In a later report, Westveld (15) warned against "broadcast" weeding as being expensive and of limited value. He recommended only enough weeding to remove severe overhead competition, but to leave smaller hardwoods as trainers for crop trees.

The suppressing effect of old-growth hardwoods upon young spruce and fir represents a serious problem in spruce-fir silviculture, especially in spruce-hardwoods types. Considerable experimental work has been done to test the feasibility of removing this competition by girdling the hardwoods.

Westveld (12, 13, 16, 17) found benefits of girdling threefold: (a) higher percent of coniferous reproduction; (b) faster height growth on saplings and small poles; (c) increased volume growth on larger trees. He recommended that careful selection be made of trees to be released so that no unnecessary girdling would be done. Essentially the same results were obtained by Robertson (9) and Best (3) in Quebec, Churchill (5) in New York, Baldwin (1) in New Hampshire, and Cary (4) in Maine. Westveld (16) estimated cost of heavy and moderate girdling at $2.60 and $2.00 per acre respectively. At the end of 20 years he found the volume of spruce on the plot that had been heavily girdled to be 1,607 cubic feet per acre, as against 974 cubic feet on the moderately girdled plot and only 172 cubic feet on the check plot.

Baldwin (2) made time studies on girdling of beech, birch, and maple. Average time for girdling a 22-inch tree was 230 seconds by notching, 259 seconds by peeling, and 73 seconds by hacking. He found that in an 8-hour day one man could girdle 2.8, 1.9, and 6.1 acres respectively by the three methods enumerated.

SOME ADVANCE REPRODUCTION IS GENERALLY PRESENT

A fortunate circumstance in this region is the ability of spruce and fir to germinate, survive, and grow under a fairly dense overstory. Some advance reproduction is almost invariably present prior to logging, and the securing of an adequate stocking of spruce and fir is not likely to present a problem under management except under some conditions mentioned below. Westveld (14) after an exhaustive study of natural reproduction following cutting on softwood and mixedwood types, reported that spruce and fir reproduction on the spruce flat types suffers little from hardwood competition. On the red spruce-yellow birch and red spruce-sugar maple-beech types, however, the representation of spruce and fir decreased after cutting and hardwoods and weed species became dominant in the subsequent merchantable stand. In the first case shallow soils and poor drainage represent conditions favorable for softwood reproduction and unfavorable for hardwoods. In the latter case, with deeper and more fertile soils and good drainage, conditions are ideal for hardwoods, which are then able to crowd out spruce and fir. Westveld claimed that in all types little new spruce or fir reproduction came in after cutting. What developed in nearly all cases had been there before cutting. Only hardwoods were found to seed in successfully after cutting.

There was evident everywhere after cutting an increase in the proportion of fir to spruce. Westveld states, however, that "since these stands are normally stocked with advance reproduction and the relative representation of spruce and fir in the future stand is already largely determined, it is questionable whether any scheme of cutting will have any material effect on the relative abundance of spruce and fir in the next crop of pulpwood." Moderately suppressed spruce and fir responded vigorously in height growth following removal of the overhead canopy, but fir averaged about a third greater growth than spruce.

According to Murphy (8) open grown spruce on a good site will bear heavy seed crops by the 30th year, while in dense stands it will be 15 years later before a good seed crop is borne. He observed that the time of first good seed year is less a matter of age than size and position of crown in relation to sunlight. Seed mature in the fall but many of them remain on the tree until spring and germination may take place then or in the following fall. On the average, 50 percent of the seed are germinable. Murphy points out two distinct advantages balsam fir has over spruce--frequent and plentiful supplies of seed, and more rapid growth in the seedling stage.

Moore (7) found germination of spruce satisfactory on mineral soil and on decomposed organic matter that were medium acid and neutral respectively. Germination and survival were poor on raw humus even when attempts were made to keep it moist by artificial watering. He concluded that spruce does best on sites with abundant moisture while fir is able to grow well on drier sites.

Long (6) concluded from his studies in the Maritimes that the principal reason for failure of spruce reproduction was the short primary root developed after germination, which does not penetrate deeply enough to get below the dried surface soil. He calls attention to the fact that fir seed is four times as large as spruce and the primary root grows much faster and gets down to favorable moisture conditions before the dry season sets in. Moisture and depth of raw humus are the controlling seedbed factors, and are controlled by climate and site.

LOGGING SLASH—WHAT TO DO WITH IT?

Murphy (8) considered spruce slash a serious fire hazard and recommended piling and burning. The effect of hardwood and softwood slash upon reproduction was studied by Westveld (13, 14). He found that at higher elevations slash decomposition proceeded more slowly than at lower elevations. Hardwood slash is pretty well disintegrated in 7 years while softwoods, being resinous, take nearly three times as long. "Heavy accumulations of softwood slash not only crush and kill advance reproduction, but prevent the establishment of new reproduction for 15 to 20 years." Westveld recommended piling and burning of slash during or after logging, depending upon the season, though he estimates the cost at around 50¢ per cord. Method of cutting—or volume removed—was found to be the controlling factor in amount of area covered by slash.

Spaulding and Hansbrough (11) found average periods required for slash to disintegrate were 15 years for hardwoods and 29 years for red spruce. Even under most favorable conditions for decay these periods would be shortened by no more than a fifth. Primary factors controlling decay are temperature and moisture, and decay resistance of the wood. Temperatures above 70° are needed for most rapid decay, and slash must be neither dried out nor water-logged. Slope, aspect, and elevation are also important, but cannot be changed by man; also they are in most cases obscured by other effects. Two effects of a short rotation in reducing slash hazard were pointed out: Less slash accumulates, and what there is usually has a higher percentage of sapwood, which is less resistant to decay than heartwood. Partial cutting, besides permitting a shorter cutting cycle and rotation, results in conditions more favorable for slash decomposition. Clear-cutting opens up the stand excessively to sunlight and drying air-currents, with the result that much of the woody slash becomes dry and case-hardened. Partial cutting, however, opens the crown canopy enough to permit some drying, but shadow-movement across the forest floor during the day prevents excessive drying, thus favoring rapid decay. Scattering of slash is recommended over piling, as decay proceeds at a faster rate when spread out. Lopping is also recommended in coniferous slash, although it is expensive, and should not be practiced on wet sites because waterlogging of slash slows down decay. The writers did not consider that accumulations of slash represent hazardous conditions from the standpoint of breeding fungi or insects harmful to living trees.

REGIONAL PROBLEMS—ABOVE AND BEYOND SILVICULTURE

AFTER CANADIAN LABOR—WHAT?

PROBABLY THE MOST URGENT problem confronting the pulp and paper industry in this region for the past 5 years has been labor. While the industry is far from unusual in its inability to maintain an adequate, steady, reliable labor force, it is in the unique position of depending consistently, year in and year out, upon foreign labor for more than half of the wood it consumes. While Canadian labor has its advantages—in general the Canadian woodsman will do more work at a lower rate of pay than the American woodsman of the same ability—it is subject to the demands of Canadian agriculture and industry. An economic expansion in Canada in the next few years may sharply reduce the number of men available for work in Maine.

Inability of companies to obtain and maintain American labor has been attributed to a number of factors. In the first place, there is not a large enough reservoir of men willing and able to cut pulpwood. And a high percentage of those able to do it are no longer willing. In the second place, camp conditions are anything but attractive. The operators themselves admit it, but as long as Canadian labor—undiscriminating to say the least—is available there is not likely to be any real reform.

Finally, the work is hard. While most other jobs have become at least partly mechanized, by far the bulk of our pulpwood is cut with the bucksaw and loaded by hand. The climate provides a depressing series of unpleasant conditions which make woods work tiresome, nerve-wracking, and unhealthy.

The answer to the problem lies partly in mechanization. A further possibility—though one which is still a long distance off—is the permanent forest community, whereby small settlements are set up and maintained by the companies at strategically located points throughout their holdings. Good homes instead of bunk-houses would be made available, and the families would be provided with enough agricultural ground to raise most of their food. The success of such a development would depend upon the company's willingness to invest in the future, and to accept as an established fact the necessity for better management of their holdings.

Along with the problem of labor availability goes the somewhat dependent problem of educating labor to better cutting. The labor shortage has bred a complete indifference on the part of the cutters to the wishes of the company as to logging practices, and better cutting practices could be enforced only at the risk of an empty camp. A carefully thought out program of enlightenment emphasizing the pocketbook theme rather than that of conservation may result in a more malleable labor force that could be trained to the principles of better forest practice.

HARDWOODS DON'T FLOAT

The region abounds in generalizations, many of which have become accepted as "fact". One that has been gaining ground in recent years is that we can grow more wood, acre for acre, in the spruce-fir region than can be produced in the southern pine region. We shall have the answer to that one some day, but at present it is rather academic because we cannot use what we do grow.

The hardwoods throughout most of the region never have been "merchantable" because they could not be driven down rivers—and they may never be merchantable now because they are mostly dead or dying.

This problem of disposal of hardwoods has been and will continue to be inextricably tied to the opening up of wild areas to reduce the overpowering influence of economic inaccessibility. If hardwoods had been "accessible" at the time of softwood logging, a market would probably have been developed. Since they could not be logged, they developed to a ripe old age and have fallen prey to various borers, cankers, scales, viruses, and beetles. If the present decadence of beech and birch had not advanced so far, our inability to dispose of these species might not be such a catastrophe. As it is, the development today of a market for all the hardwoods that could be supplied would be of limited benefit because they are too far gone. To be sure, there has been an expansion in mill capacities for hardwood pulpwood. But the four mills drawing upon this region for their supplies of beech, birch and maple pulpwood account for less than 150,000 cords annually out of a capital stock estimated in 1940 of more than 100 million cords.

Future stands of hardwoods should have markets waiting for them. By increasing accessibility, developing new uses and markets for the intermingled hardwoods in the spruce-fir region, and carrying along research in hardwood management we can keep chipping away at this problem. But by and large, we stand to lose millions of cords of beech, birch, and probably maple, no matter what we do.

THE BIG PROBLEM—AS ALWAYS—IS TRANSPORTATION

Under the present transportation system, movement of men and materials into, and wood out of much of the wild land area can be done only over water or, in the winter, over snow or ice. This does not make for mobility of operations, and the inner portions of the trackless wilderness can be reached for logging only in their turn, as the camps advance, year by year, up the tiers of townships from the outside. The result, as has already been mentioned, is not only wasteful but expensive. An inordinate amount of swamping, bulldozing, clearing, building, plowing, toting, hauling, and other laborious comings and goings consume a tremendous amount of time which could be used to far better advantage if a permanent road system permitted easy access.

Most companies are now beginning to realize the value of permanent road systems and are pushing them through the wilderness ahead of, or along with, logging operations. But it is a slow process and for a good many years large groups of townships will remain "inaccessible" with thousands of cords of spruce and fir being lost yearly through decay and windthrow, in addition to the hardwoods mentioned above.

THE THEORY OF STUMPAGE RESERVE

Pulpwood operators generally estimate that they can buy wood delivered to the mill for about 70 percent of what it costs them to produce their own. In a sense, the added cost of wood from company lands is the price paid for inaccessibility. The costs of construction and maintenance of camps, winter haul roads, dams, booms, and storehouses, the depreciation and cost of upkeep of expensive road building and logging equipment, salaries of administrative and supervisory personnel, and other expenditures inherent in large and complex operations (see table 9, appendix, for a

hypothetical example of production costs) are ones which the small woodlot owner does not have to meet. Furthermore, the large tracts of company timber are becoming more difficult to reach. As supply lines are extended farther and farther into the interior it costs more to bring men, equipment, and materials to the job, and more to get the wood out.

As a result of the difficulty of getting "cheap wood" from company lands, more than a quarter of our pulpwood is imported and a third is purchased within the region by the pulp and paper companies from the small timberland owners, mostly farmers. There has been a tendency on the part of the large operators to depress the price of open-market wood by drawing more heavily upon their own holdings whenever the price of purchased wood starts going up. By buying from a third to a half of their mill requirements they are able to keep enough of a reserve behind them that they can for short periods of time go off the market entirely if need be to bring the price down.

This is not a happy situation from the standpoint of the small landowner, and it also results in a deliberate holding back of merchantable timber on company lands that could be operated. The "savings" occasioned by purchasing wood at a lower price are at least partially offset by loss of their own stumpage due to decay and windthrow. In some cases, this procedure benefits the land, in that purchasing wood sometimes permits the holdings of the paper company to "recuperate" after cutting, where otherwise a second operation would be made too soon. More often, however, it results in not cutting timber that is mature.

THE PARADOX OF THE SMALL OWNERSHIP

A further complicating factor that enters the picture is the competition among companies for purchased wood, and the manner in which it is handled. Because of the high degree of accessibility of most small woodlots, and because of the pulpwood "buyer" or "dealer" system, pulp and paper mills can afford to purchase wood trucked over great distances. As has already been mentioned, it can be bought in this manner at a lower cost than wood can be produced on the paper companies' own holdings. The result is a maze of feeder lines from all parts of the State to nearly all pulp and paper mills in Maine and to some outside states. For example, in the Washington-Hancock County area, buyers for nine companies—

Eastern Pulp Wood, Eastern Corporation, St. Regis, Pejepscot, Oxford, Dead River, Kennebec, Penobscot Chemical Fibre, and Great Northern—are competing for the products of small woodlots. The same situation in a greater or lesser degree holds true throughout the region.

At first glance it would appear that with this choice of markets the small woodlot owner is in an ideal position. He could offer his product to the highest bidder. He could insist upon almost any reasonable amount of good forest management as a condition of the sale. Stumpage could be sold in small quantities, hence frequent, light cuts could be applied. The end result could be the practice of good to high-order management upon the small ownership. However, just the opposite is true—the small holding is the worst managed in the region.

One explanation lies in the fact that most owners neither know nor care about better woodlot management. Too often the decision to cut is the result of a need for some extra cash. Unhappily, perhaps, there is usually a market for both hardwoods and softwoods because of the strategic position of most woodlots with respect to arteries of transportation. The owner generally feels that while he is at it he had better get all the cash he can from the sale. As a consequence he cuts, or sells as stumpage, everything merchantable.

This apathetic owner attitude toward forest management is not likely to improve substantially as long as the traditional modus operandi of the pulpwood buyers prevails. Most buyers or dealers work on a commission basis, receiving only $1 a cord for the wood they sell to the companies; and they count on supplementing this margin of profit by making close deals with the woodlot owner. To this end, they either buy the woodlot—land and all—for as low a price as they can, or buy stumpage on a lump sum basis; but in either case they strip the land of all merchantable pulpwood. They thus try, and usually succeed, in making an extra dollar or more per cord at the expense of the woodlot owner. Under this system the owner of the woodlot finds little reason to regard the growing of timber as a profitable enterprise.

It should be remembered that of the 13.5 million acres of forest in this region, 3.4 million, or about 25 percent, are in small ownerships of less than 500 acres. Thus, the problem of bringing better cutting practices to the small ownership represents a pressing problem from the standpoint

of acreage; an even more pressing one from the standpoint of present operational practices. Instead of taking fullest advantage of accessibility, ready market, and low production costs to take the lead in better forest management, the small owner does the poorest job.

REGIONAL PROBLEMS—GETTING BACK TO THE WOODS

THROUGHOUT BOTH THE SPRUCE-FIR and hardwood types of the region stands are depleted, volumes are low, and growth rates are far below the latent ability of the sites to produce wood. One of the outstanding features of the forested area is its potential productivity. We need to develop, test, and perfect techniques that can be used in a workable and practical manner to improve stocking and to control composition. Failure to increase productivity of, and net returns from, the forest lands will affect adversely the economy of the State and may eventually have a pronounced influence upon that of all New England.

The contributing causes of low productivity, examined and analyzed minutely, will be found to overlap and interlock. The correction of one phase will be dependent upon, or at least influenced by, remedial measures for most of the others. In the final analysis, however, it will be a combination of technical know-how plus well-grounded facts on costs and returns of management operations in the woods that will raise the level of productivity in the spruce-fir hardwood region of Maine.

FIRST THINGS FIRST—CUTTING PRACTICES IN OPERABLE STANDS

Dominating the entire picture of forest management is the failure of present cutting practices to maintain continuous production on an area, to permit realization of the growth potential of the land. For the most part, wood is harvested in 4-foot lengths, principally for pulpwood. Trees down to and including 6.0 inches d.b.h. have been, and still

are, considered merchantable in most operations. On dominant softwood sites, the so-called "stumpwood" system has generally been followed, although some companies, recognizing its destructive after-effects, are trying to get away from it. This is the original "stripping" process, resulting in 15 percent of the stand—or more, depending upon stand density and tree size—completely cleared of all vegetation for sled roads. While diameter limits are theoretically set at a "7-inch stump" on such operations, it is not uncommon for spruce and fir 5 or 5½ inches at the stump to be cut, especially if the stand is a young one. Moreover, the residual growing stock of small trees 1 to 5 inches in diameter is heavily damaged by logging, windthrow, sunscald, and drying out of the soil under sudden and extreme exposure. These trees, usually ranging from 40 to 60 years of age, must often be written off as a complete loss in many cases.

In mixed spruce-fir-hardwood types site deterioration has not been so severe, except where both hardwoods and softwoods have been removed, as is frequently the case on small woodlots. Stand composition has suffered, however, and effective growth on merchantable species has been badly retarded. Even under somewhat better harvesting practices, as when the wood is peeled and where tree-length yarding is practiced, the growing stock is depleted to a dangerously low level, and the fastest-growing size classes are cut. The cutting cycle still averages 40 years or more on all but exceptionally good sites.

Fundamentally and naturally uneven-aged and readily adaptable to some form of selection cuttings, spruce-fir and associated types can be maintained continuously productive by short cutting cycles. Composition and growth rate can be closely controlled by method, intensity, and frequency of cut. Wind damage, logging damage, amount of release, extent of mortality, success or failure of the residual stand to maintain itself at the highest level of productivity—all are reflections of proper or improper cutting practices. Indiscriminate clear-cutting with its attendant ills has been largely responsible for low productivity. Failure to leave sufficient growing stock in sapling and pole sizes, plus destruction of much of the smaller growth, has resulted in understocking of spruce and fir. The long period that must ensue before a second cut is economically feasible permits much of the young fir which does survive to reach and pass maturity and become defective. Site deterioration follows extreme cases of denudation, resulting in conditions unfavorable for new reproduction of desirable species.

On the basis of considerable fundamental knowledge of the behavior of spruce, fir, and better hardwoods, alternative cutting practices have been suggested. But proof of the soundness of these recommendations, the relative desirability of different cutting cycles and of growing-stock levels, and more especially, convincing evidence that added yields from such management will more than pay for added costs, must be available before ready and widespread acceptance of any management proposal can be expected.

TOMORROW'S PULPWOOD--THE INOPERABLE STANDS

As has already been pointed out, inoperable stands of spruce, fir and hardwoods cover nearly 8 million of the 13.5 million acres of forest in the region. About half these stands are stocked in varying degrees with merchantable species in sapling and pole sizes. The majority are actually understocked and are making only a half to a tenth of the potential growth the site could support. Generally speaking, a heavy intermixture of weed species is the cause of understocking. However, close study of apparently well-stocked stands reveals great lack of uniformity of stocking--too dense in some places, sparsely stocked patches dominated by wolf-trees in others. Then too, there are large numbers of defective, deformed, dead, suppressed or otherwise poor-risk trees, as well as scattered openings where brush, alder thickets, or blow-downs occupy growing space.

This inadequate or irregular stocking is the principal cause of the average slow growth of most immature spruce-fir stands, although site deterioration and poor diameter-class distribution also contribute to low productivity. Poor cutting practices have, for the most part, been responsible for the slow recovery of the forest, and almost nothing has been done about such stand conditions until the time of the next cut. For the future they can be left alone and allowed to develop naturally, reaching maturity with a fraction of the merchantable volume they could support. Or some type of improvement measures can be imposed to shorten the interval until the next cut and increase the yields.

Immature stands are the operable stands of tomorrow. They are also the residual stands of the day after tomorrow when better cutting practices have been adopted. Thus, we have a double responsibility: to increase stocking, improve composition, stimulate growth and reduce loss from insects,

diseases, and windthrow of the depleted stands we now have; and to find out in exact and specific terms what kind of residual stands we wish our better cutting practices to leave us in the future. If, by placing a thousand acres of immature spruce and fir under management, the ultimate yield can be increased 25 percent, it will make the job of imposing proper harvesting practices infinitely easier when the tract attains operable size. And if we can learn what constitutes optimum stocking, most desirable composition, and the best balance of size classes in such immature stands, we can define marking rules and cutting specifications for the harvesting operation aimed at attaining in the residual stand precisely the stocking, composition, and size-class distribution that will give us the maximum growth.

THE LONG PULL—REHABILITATION OF NON-RESTOCKING AREAS

The other 4 million acres of inoperable stands represent an entirely different problem. For the past 25 years about 200,000 acres have been cut over in the region annually. Cutting practices, as indicated above, have left a limited growing stock, and that mostly in the 1- to 5-inch diameter classes.

Where there had been a good stand of advance reproduction the recovery of the site has been reasonably good--even though slow-- provided logging damage was not too severe. For Nature does pretty well at re-establishing spruce and fir if she is given half a chance. But where there was no cover of advance reproduction beneath the merchantable stand, or where the combined effects of logging and unfavorable site conditions caused its virtual extinction, the land has come back to ferns, associated herbaceous plants, wild blackberries, hazel, alder, gray birch, and red maple. And--ultimately--spruce and fir.

On the mixed softwood-hardwood sites the more aggressive weed species--particularly red, mountain and striped maple, and witch-hobble--have come in, and dense clumps of other hardwood sprouts have sprung up. The spruce and fir reproduction already established has been crowded out, and even yellow birch and hard maple reproduction has been badly suppressed. On neither softwood nor mixedwood sites are conditions favorable for germination and survival of spruce and fir seedlings.

This situation is critical on about 2 million acres of cut-over land. An additional half-million acres of recent and old burn is in the same condition. More than 100,000 acres are being added to the total yearly from new cuttings and burns. Allowing Nature to take her course--which is sure, but terribly slow--is estimated to require from 80 to 100 years for desirable species to become re-established, overcome competition, and reach merchantable size on denuded areas. Whether or not anything can be done within the realm of practicability to improve conditions on such land and so reduce the long interval between cuts should be a matter of careful research. Here again, the problem will not only be to find out what cultural treatments will be effective, but of equal importance will be the cost of any such treatments and whether that cost will be justified.

AND NOW, TO CURE THE AILMENT...

In the application of research techniques to solve the problem of stand depletion and slow growth, the real urgency lies in improving cutting practices to be applied to operable stands. On the millions of acres of depleted or denuded lands the damage has already been done; the situation there will not worsen with the passage of time. But on the 200,000 acres of operable forest that will be cut this year, and on the 200,000 acres to be cut next year and the year after, the damage has <u>not</u> been done--yet. Obviously, the modifying of poor cutting practices is a <u>preventive</u> to the creation of new areas that would otherwise become <u>corrective</u> problems in the second and third categories as outlined above. An acre saved is two acres gained. Also, the application of sound silviculture to mature stands should produce returns more easily and quickly than would, for example, rehabilitation treatments on denuded and waste areas.

Indications are that the institution of better cutting practices can be made with little immediate additional cost. The benefits of improved operating methods to be derived over a long period of time should not only be at once apparent to the timberland owner, but it should be possible to evaluate them in dollars and cents in advance of cutting. Furthermore, there is a slowly gathering sentiment in favor of improved cutting practices on the part of some of the large timberland owners. The acceptance of improved cutting practices by any one company might well make such practices effective immediately on ten or fifteen thousand acres annually. The demand

for technical information, and for evidence of economic practicability of forest management is nearly here, and we must be well prepared to supply that demand with the necessary information based on our research findings.

For the problems of immature stands and non-restocking areas, the initial approach will undoubtedly be through the small woodlot owner, more specifically the farmer. In his spare time he himself can do the thinning, the weeding, the planting, and the girdling, acre by acre. As a long-time investment, timber-stand improvement on non-restocking areas (including planting) may be found to pay well, but the current need and the urgency for this type of research is not nearly so intense as the need for information on best methods of cutting. In the long run—by the time results become available—the need for proven rehabilitation measures is expected to be great.

...WHAT IS THE TREATMENT?

For this region the research aimed at developing improved forest management should be sharply divided into two parts: that aimed at intensive practices that can and should be applied by the small owner, and that aimed at the more extensive practices adaptable to large and more inaccessible ownerships.

In most cases the small owner could easily apply certain cultural treatments to his tract. The small owner could, if shown that it is profitable to do so, adopt short cutting cycles down to and including yearly cuts. In other words, he might well consider <u>High-Order</u> cutting practices.

The owner of half a million acres, on the other hand, is not now and probably will not be for several decades, in a position to thin, weed, plant, or prune on any but a partial scale. Within the foreseeable future, however, the goal for large holdings will probably be 20 years as an average practical cutting interval under the selection system of silviculture, with extremes of perhaps 10 and 30 years. The target of large owners might well be <u>Good</u> cutting practices, with <u>Fair</u> practices appropriate for the most inaccessible tracts.

The physical structure of the research program, the specific treatments to be explored, are inherent in the

uneven-aged or selection forest characteristic of spruce-fir types. As is usually the case with tolerant species, initial growth is slow. Invasion of rapidly growing but less tolerant species makes control of composition a primary objective. To insure the maximum return, stocking must be built up and maintained with simultaneous and continuous control of diameter-class distribution. The tools or treatments recommended for accomplishing both the above, and the two principal variables to be tested, are frequency of cut—cutting cycle—and intensity of cut, or amount of growing stock maintained. These are, of course, overlapping in their effect, and one cannot be considered without the other.

Also impinging upon the elements of cutting cycle and residual stand is the question of end product to be grown. While the region's forest industry hinges upon a pulpwood economy, there is nearly always a good market for locally produced lumber. Furthermore, a more diversified marketing program might well bring a higher return to the small forest owner. On paper company holdings woods managers are reluctant to permit trees to attain a diameter of more than 13 or 14 inches because of a supposed increase in production cost. At any rate, it should be made a matter of record where the point of diminishing returns lies in relation to tree size. For this reason, there should be a careful test of small vs. large trees as a silvicultural objective.

There will be, finally, certain types of stand-betterment measures needed to speed up attainment of optimum stand structure, and rehabilitation of run-down forest land. A good back-log of basic knowledge is already at hand relative to the effectiveness of girdling, thinning, and weeding in promoting growth of desirable species. But the economic aspects of timber-stand improvement must have careful study, and some of the technical refinements need further exploration.

It seems probable that for some time to come the adoption of such treatments, and of pruning and planting, will be confined principally to small woodlot owners. This makes stand improvement none the less important. The small owner not only supplies a third of the wood requirements of the region, but is strategically situated with respect to his ability to have a higher level of cutting practice applied on his lands.

AND WILL IT BE WORTH THE COST?

While one objective of the research job is to discover methods and treatments that will meet certain silvicultural objectives, the results of such research may be of little more than academic value unless the effect of the recommended treatments upon costs and their ability to increase returns is known. Recent information on the costs and returns of forest management and silvicultural measures is relatively meager in the region as a whole. Some emphasis has been given to general studies of financial aspects of partial cutting in spruce-fir, and most of the larger wood-using firms have obtained a considerable bulk of cost information from their own operations. However, it is difficult to adapt such information to specific forest-management objectives because, in general, it pertains only to present cutting methods. Not only do bookkeeping records vary widely from company to company, but each is naturally reluctant to disclose its costs of production.

Reduced to its simplest terms, the costs-returns problem means weighing logging costs against wood yields over a long period of time. The picture is much more complicated than that, however, as it is not simply a matter of testing such elements as yarding vs. stump cutting, tractor vs. horse, and winter vs. summer logging. Long-range growth predictions have to be matched with long-range cost estimates, such as the relative investment of one set of camps on a 60-year cutting cycle against three sets on a 20-year cycle. The effect of transportation costs, prices, supply and demand, and availability of labor upon intensity of management and utilization have to be analyzed. The increment from any merchantable portion of a stand left as growing stock under a selection system must be compared with interest rates to be expected from an equivalent amount of invested "stumpage".

Many advantages possibly inherent in improved forest management must not be overlooked. What will be the effect of stand density upon cost of selective logging? Will there be an appreciable increase in solid wood content of a cord under partial cutting? What will be the saving in stumpage occasioned by reduced loss from decay and insects which will presumably come with management? Will there be a reduction in fire hazard and an increase in fire risk under management? If so, which will prove to be of greater significance? Does integrated utilization pay? These, and many other questions must be anticipated, and their answers gradually worked out as part of the permanent research program.

SOME OTHER PROBLEMS NEED ATTENTION

These are the big problems of the spruce-fir region, the major jobs to be done before the full power of the land to grow wood and earn income can be achieved: to improve cutting practices in operable stands; to hasten the development of immature stands; to rehabilitate non-restocking areas. The doing of these jobs will obviously require a perfected technical skill. But, of equal importance, it will require knowledge of the nature of costs and returns associated with the application of that technical skill. The product of these two will be the level of cutting practice best suited, silviculturally and economically, to any forest tract. To this end most of the research program of this Center for the next 5 years will be devoted.

But there are aspects of these major jobs that constitute individual problems in their own right. And we are finding unanswered questions in closely related fields of research impeding our progress toward attainment of our primary goal. Many of these problems and questions cannot be ignored for long, and in the following paragraphs some of the more important ones will be analyzed.

Administration Of Forest Holdings

As has been previously mentioned several times, the last 5 years have seen the beginning of a new philosophy on the part of the large industrial timberland owners toward their holdings. There is a growing concern over adequacy of wood reserves, proper balance to be maintained between purchased and operated wood, and the allocation of operations. The need for a more orderly organization of properties with respect to cutting schedules has been recognized.

Through it all there has been the almost imperceptible emergence of what is, to the large timberland owner, a new concept: the management plan. Unlike management plans on national forests, which have long been administrative practice, the development of management plans for the large, often widely scattered holdings of the paper companies will probably be trial-and-error propositions slowly and inefficiently achieved. Objectives are different from those on national forests, and pressures and influences that will mould them will also be different.

It should be the responsibility of the Penobscot Research Center to provide technical advice and guidance to the large companies—and to other owners as well—in their attempts to prepare management plans and place their holdings on a sustained-yield basis. Such action by owners or managers of forest land is undoubtedly the preface, and a necessary preface, to the adoption of better cutting practices. Much can be done at the experimental forest level to try out procedures, to test methods, to explore simplified practices that may be adaptable to needs of those who want to begin more orderly and systematic sustained-yield management of their holdings.

Growth In Unmanaged Stands

The problem of growth in managed stands will be pretty well taken care of in the studies of growing-stock control included in the broader studies of various levels of cutting practice or forest management intensities. But with the developing trend toward better forest land administration just described, there is also a current need among timberland owners for more precise information on the growth of existing unmanaged stands. Longer range plans and policies involving more detailed inventory and growth reports are becoming standard company policy. Investments in aerial photographs have been accepted as essential. Now there is realization that traditional procedures whereby "allowance" was made for growth are grossly inadequate.

For the vast areas of as yet unmanaged forest we need to know how fast stands cut over some years ago are putting on growth, how soon they will be ready to cut and what volumes they may be expected to yield. We should be able to evaluate the variation in growth by site, type, stand age, and condition class. And part of the problem is the rather elementary one of setting up procedures and techniques for obtaining the information we want as inexpensively as possible.

Logging

To say that the principal problem to be solved in logging is that of mechanization would not be saying a great deal. Mechanization, of itself, in the form of a sort of "industrial revolution" blanketing the region with mechanical

contrivances for felling, peeling, bucking, skidding, loading, etc. may not be entirely desirable or feasible. What is most needed is the development of specialized machinery designed specifically for pulpwood conditions, and a careful testing of such machinery under all possible conditions to which it might be exposed. The greatest needs at present are an efficient, portable barking machine, a small compact, easily maneuverable tractor for yarding, and a mobile and highly flexible pulpwood loader. Two notable trends in logging at present are toward peeled wood and away from rough wood, and toward yarding and away from stumpwood. Both represent desirable trends insofar as better silviculture is concerned, and should be encouraged in any way possible.

As important as the equipment itself is the manner in which it is used. Some of the so-called failures of mechanization in this region have been failures in job organization. Not enough thought has been given to revising traditional procedures to make them work smoothly and efficiently with machines. The chain saw is a good example of a piece of equipment that needs an entirely new crew organization.

One of the principal limiting factors in the production of peeled pulpwood has always been the short sap-peeling season. Softwoods can be peeled only from early May until early August, and the period is generally about 4 weeks shorter for hardwoods. It has been thought for some time that poisoning trees with the right chemicals at the right time of year might result in the bark becoming loosened as the tree dies, making it easy to peel for an indefinite period of time. Preliminary studies have already been made in the Northeast, notably by the Armstrong Forest Products Company in Pennsylvania, with encouraging results. In view of the growing demand for peeled spruce, fir, and hemlock, it should be determined whether and under what conditions "poison-peeling" can be applied to these species.

Insect And Disease Control

Yearly damage to forest stands from insects and diseases is very difficult to appraise for several reasons. Only a spotty survey of damage is possible and application of sample damage figures to the region as a whole presupposes a reasonably accurate estimate of volume or acreage of species affected, which is not available. In attempting to measure loss in terms of dollars and cents, intelligent estimates of

damage to sub-merchantable size classes, and to so-called intangibles like scenic value, watershed protection, and site quality, are especially difficult. The figures previously quoted of average annual loss due to insects and diseases of 80 million cubic feet are probably conservative, but are the best available. At $3 a cord stumpage this would represent an annual loss of nearly $2,500,000.

It is a well-established principle that good forest management can be an effective tool for the control of much of the insect and disease damage. By creating and maintaining healthy, fast-growing stands, and by controlling composition, the forest manager can prevent the development of most epidemics and infestations, and nearly eliminate damage from less serious pests. The ground work for making some definite recommendations in regard to silvicultural control of the spruce budworm has been laid in the last 5 years. These studies will be continued. In addition the staff of the Penobscot Research Center should be aware of the importance of insect and disease damage, and should be prepared to initiate further studies in the event of future outbreaks.

There is a need for research on physiological processes of trees as has been indicated many times during the last 4 years by the questions that have arisen in connection with the budworm program regarding tree maturity and flower production of balsam fir. The budworm program, in fact, opened up extensive vistas of possible research ranging from the merely "interesting" to the highly important. Relative efficiency of new vs. old foliage, for example, in carrying on photosynthesis has a direct bearing upon silvicultural treatment of stands in advance of the budworm epidemic.

The significance of balsam fir rots has already been mentioned in connection with decadence and windthrow of this species in overmature stands. The causal organisms have been identified and their manner of operating has been fully described by Spaulding and Hansbrough (10). Future research should be centered about three problems: (a) likelihood of balsam fir in the 4- through 7-inch classes, currently being left after cutting in order to build up stocking, to develop decay during the next cutting cycle; (b) means of detecting the presence of various rots to permit a more complete culling of defective trees under intensive management; (c) determination of tendency or "prone-ness" of fir on certain sites or in certain compositions to develop decay. Once these three problems are solved, heavier or lighter cutting of fir may be made according to stand or site conditions.

Individual Tree Growth

Partial or selective cutting has long been recommended as the best system of silviculture for most spruce-fir stands. In "High-Order" and "Good" levels of cutting practice, and possibly in certain cases in the "Fair", all trees to be cut are marked. In actual practice it is more frequently the trees that are to be left rather than those to be cut that are "selected", because the objective of the marking is to provide the best possible growing stock appropriate to the level of cutting practice being followed. Of course the amount of mature volume to be cut also exerts some influence on the marking, but primary consideration is given to the building up of the growing stock, or to its maintenance once it has been built up.

On this basis, intelligent marking depends upon correct evaluation of the tree's ability to survive, and, surviving, to earn income through the next cutting cycle. It also depends upon the forester's knowledge of what to expect from a tree after it has been released following cutting. The most certain way of assuring an accurate and uniform appraisal of tree "risk" is to base every decision upon consideration of reliable indicators of the tree's condition. Considerable background knowledge of spruce and fir growth in terms of tree characteristics has been built up, but further studies are needed, especially with respect to the response of trees to release. The development of a simple, workable tree classification is also a project worth the early attention of this research center.

Management Of Minor Species

White birch supports a great multitude of turnery plants, spool mills, and other establishments making miscellaneous small products throughout the region. Most of these mills are in small communities and are often the principal source of employment. Very little is known about the management of this species. Research devoted to learning the optimum rotation (under even-aged stand management), best means of obtaining natural regeneration and possible stand treatment to promote better growth is well justified. To a lesser extent, the same is true of northern white cedar; it is, of course, a specialty species and production is low--less than 20 million feet annually. Its use (although

diminishing) for shingles, posts, and ties makes it unique among species in this region, however, and more information is needed relative to its management and utilization.

Forest Soils

Little has been done in the region to study the relation between soil qualities and tree growth. It is generally recognized that drainage and depth of soil are controlling factors in forest-type distribution, but almost nothing has been done on fertility. We know in a general way what the moisture requirements of spruce and fir are, but we do not have them related to age and development of tree. Nor do we know much of the nutritional requirements of our principal species. Here forest soils and tree physiology effects meet and overlap, and the whole subject bears directly upon previously mentioned determination of growth and yield potentials of various sites for different species. Much work of a fundamental nature remains to be done.

Recreation And Wildlife

The importance of recreation in the region's economy has already been mentioned: a significant part of the region's income derives from hunting and fishing, both of which are highly dependent upon forest cover. No attempt has been made to completely analyze forest-wildlife relationships, but the need for study and research is illustrated by one problem currently causing great concern in the State.

Fishing in our brooks and lakes is becoming progressively poorer. Biologists believe that as fish population decreases food supplies increase and fish refuse to bite. The decrease in population is attributed to conditions becoming less favorable for spawning fish than in the past. Clear-cutting is blamed for raising the temperature of the water, presumably by wholesale exposure of large areas to the sun, and permitting silting in of stream bottoms. Other factors are undoubtedly involved, such as more rapid runoff, greater fluctuation in stream flows, etc. Pollution in some areas has contributed to this problem.

A further analysis will be made in the future to determine any appropriate studies that might be undertaken.

THE RESEARCH PROGRAM TO BE UNDERTAKEN DURING THE NEXT FIVE YEARS

THE PRINCIPAL PROBLEMS confronting timberland owners and woods operators in the spruce-fir problem area of Maine and northern New Hampshire have been analyzed in the preceding sections. Some of the economic and social forces that have influenced the history of the wood-using industries have been examined; some of the reasons for the present condition of our forests and for the cutting practices employed have been sought out. Thus far no attempt has been made to set up priorities among the problems. However, an efficient and effective attack upon those problems must be launched from a specific and logical plan. This must be our next step.

In the following pages are listed the projects that should constitute the research program at the Penobscot Research Center for the next 5 years. This program will command the major effort of the research centre staff and the part-time participation of specialists from the regional headquarters of the Northeastern Station at Upper Darby.

Pilot Operation--Spruce-Fir Type

A study of the possibilities of the different cutting practice levels should go a long way toward solving some of the problems of silvicultural and financial feasibility of forest management. The principal variables to be tested in such a study would be cutting cycle, amounts of stand betterment, and product objectives. Such operations would be conducted on the Penobscot Experimental Forest on a pilot-size basis, and should furnish answers to such questions as the following:

- What are the costs of the various levels of cutting practice in relation to their returns?
- What cubic-foot growth per acre per year may be expected on different sites from application of "High-Order", "Good", "Fair", or "Poor" cutting practices?
- What is the optimum stand structure with respect to stocking, composition, and diameter-class distribution?

- Is it necessary to mark timber to realize a fair proportion of the growth capabilities of forest land?

- Is it necessary, even under "Fair" cutting-practice level, to conduct some stand betterment that will not currently pay its way in order to keep the forest from deteriorating below the level of "reasonable productivity"?

- What are the silvicultural difficulties of the various levels of cutting practice as viewed from the standpoint of practical applications?

- What are the relative financial merits of growing pulpwood alone, and integrated with production of saw timber and other products?

Three or four pilot-size operations (about 40 acres each) will be directed toward the special problems of the small woodlot. Emphasis will be placed on annual cutting and ways in which the farmer can use his own labor and equipment. But attention will also be directed at determining what the non-farm woodlot owner can do to improve his cutting practices.

The selection system of silviculture resulting in uneven-aged management is generally conceded to be ideally suited to most spruce-fir stands, and most of the management research will be based on that principle. However, a few 40-acre pilot-size compartments will be handled on a shelterwood system of cutting to determine whether and under what circumstances this system is desirable.

Rehabilitation Of Non-Restocking Areas

On much of our formerly productive land heavy cutting or fire has resulted in a persistent and dense growth of brushy species. It is planned to experiment, both on and off the Penobscot Experimental Forest, with several methods of putting this waste land back into useful production. Of particular importance are these questions:

- To what extent are desirable species already present as scattered individuals or clumps in these extensive brushy areas?

- What means of release of the scattered natural reproduction is effective and economically feasible?

- What are the possibilities of planting in such areas, and how expensive would such planting be?

When these preliminary sample-plot tests have been completed and an indication of costs in relation to returns has been obtained, the results will be used to establish specifications for appropriate levels of practice applicable to pilot rehabilitation areas on the experimental forest. These pilot tests should eventually provide a more solid basis for recommended practice.

Improved Operating Efficiency

It seems inconsistent to strive for better cutting practices but to make no effort toward a simultaneous improvement of traditional logging practices. To bring methods and techniques into closer alinement with the demands of better cutting practices and the requirements of operating efficiency, three phases of the subject need careful study: (a) mechanization and job organization; (b) logging damage; and (c) poison-peeling. It is proposed to inaugurate studies on the Penobscot Experimental Forest and perhaps elsewhere in the next 5 years aimed at answering such questions as:

- What are the comparative costs of "yarding", with tractor and with horse, and of "stump-cutting" in the production of spruce and fir pulpwood?

- What is the most efficient job organization for cutting pulpwood with chain saws?

- What degree of logging damage is associated with: different cutting practice levels?; different methods of logging?

- Can tree poisoning be used economically and effectively to extend the peeling time for spruce, fir, and hemlock?

Organization Of Properties For Forest Management And Determination Of Sustained-Yield Techniques

This problem is rapidly growing in urgency and importance. The next 5 years will probably witness a realinement of values and broadening of perspectives by the large timberland owners. Closely related to this whole problem are questions of administration of forest management. What are the simplest ways to regulate the cut? What "tools" are essential and how should they be applied? What kind of stand inventories are needed? What intensities of growth predictions are necessary? How much per acre should one expect to invest in management—not in the silvicultural and other technical operations as such, but in the planning, administration, and control of such operations? It is planned to make an analysis of this broad problem in an effort to provide a preliminary answer to the following general questions:

- How can a large, scattered, hitherto unmanaged forest ownership best be organized to insure sustained yield?

- What is the best basis for long-range allocation of cuts and scheduling of operations once an entire holding has been organized for continuous production?

Determination Of Growth In Unmanaged Stands

Unmanaged or very extensively managed stands, especially in the more remote portions of the region, will be with us for a long tome to come. The large timberland owners are, however, trying to improve operating efficiency and to establish an orderly cutting schedule. They are seriously handicapped by lack of knowledge of growth in the typically uneven-aged, unmanaged stands that make up so much of their holdings. A joint cooperative study between the Northeastern Station and a group of Maine timberland owners is now being set up and will be established in the next year, aimed at answering the following questions:

- What sample-plot techniques and other procedures for obtaining growth information will give statistically sound results at the lowest per-acre cost?

- What is the average per-acre growth of spruce and fir, and of other species, for the principal forest types and stand-condition classes?

Insect And Disease Control

Forest-management research has a very definite responsibility in the field of protection against insect and disease damage. In this region, which has seen tremendous damage to larch, spruce, fir, birch, and beech, the responsibility for developing forest-management techniques to control or reduce future attacks is especially heavy.

Experiments now under way and continuing, or planned for initiation during the next 5 years, are aimed at answering the following questions:

- To what extent does the amount of fir in a stand influence the degree of damage, including both mortality and growth-rate reduction, resulting from defoliation of spruce and fir by the spruce budworm?

- What particular modifications or adaptations of the tree-selection system can be applied to spruce-fir stands to reduce damage by the budworm?

- What tree characteristics are most closely associated with the degree of damage suffered by individual trees through defoliation by the spruce budworm?

- With what site factors, tree characteristics, or stand conditions are the presence and severity of balsam fir trunk rots correlated?

Improved Tree Selection

In the final analysis, the skill with which high-value or fast-growing trees can be recognized by the forester with the marking ax or paint gun has a profound influence upon the success of "Good" and "High-Order" cutting-practice levels. For it is the structure of the residual stand that is the key

to maximum yields, and one of the most important elements of stand structure is the condition or rate of growth of the individual trees. Studies designed to obtain more information on individual tree growth, which will permit more accurate evaluation of tree risk, will be launched during the next 5 years, and will give the answer to:

- What tree characteristics are most closely associated with rapid growth of spruce and fir?

- What tree conditions—age, height, crown shape and size, degree of suppression, etc.—govern the extent and rate of response of spruce and fir to release?

- On the basis of the above, what is the simplest and most workable tree classification that can be developed for use in marking spruce and fir for cutting under "High-Order", "Good", or "Fair" levels of cutting practice?

Management Of White Birch

Most important among the minor commercial species in the spruce-fir problem area is white birch. Although heavily damaged by the recent birch borer epidemic, this species is by no means as hard hit as the yellow birch. However, the loss of untold thousands of cords of white birch trees has intensified the need for information relative to better and faster production through management. In view of the importance of this species, a modest research program for white birch management will be launched to seek answers to some fundamental questions.

- What factors control the success of natural regeneration of white birch?

- What stand and site conditions are most favorable for quantity and quality yield?

- What silvicultural systems are adaptable to its management?

- What is its optimum rotation on various sites?

Gale River Experimental Forest

Most of the research program just outlined for the next 5 years will be conducted on the Penobscot Experimental Forest. The remainder will be carried out on privately owned forest lands in Maine and northern New Hampshire.

It is not proposed to initiate any new studies on the Gale River Experimental Forest during the next 5 years. However, any remeasurements on studies previously established at Gale River, which may come due in the ensuing period, will be made at the proper time. Other maintenance work will also be performed when necessary. It is planned, however, that the staff at the Penobscot Research Center shall become thoroughly familiar with the Gale River Experimental Forest, its past studies, and its possibilities for future research work. Beginning in 1955, or as soon thereafter as possible, an active experimental program will be reinstituted at Gale River to supplement the work being carried on at the Penobscot Experimental Forest.

* * * * *

...SUBJECT TO CHANGE

The Nation's railroads have long been reconciled to the uncertainties of a changing world. "All schedules," they warn the traveler making plans to catch the night train for Boston, "are subject to change without notice."

The foregoing attempt to analyze and evaluate forest-management problems in this region and to prepare a plan of attack upon them, will suffice for the present. But the constantly shifting pressures generated by the world's affairs can be expected to have their effect upon the policies of the large paper companies that dominate our wood economy. The problems, by and large, will remain the same. There can be no getting away from the poorly stocked, slow growing, unoperable stands that occupy 60 percent of our forest land.

But the order of emphasis upon some problems may change; needs and requirements for certain types of information may intensify while the demand for other types of data may decline. New problems may emerge from what now appears to be the beginning of a keener appreciation of the importance of our forest resource on the part of the large owners. The research planner must be aware of these possibilities, must avoid becoming a slave to a program based upon past conditions. His schedule, like the railroads' may be subject to change without notice, and should be brought up to date whenever necessary.

* * * * *

CONCLUSION

THE FINAL PROBLEM—RESEARCH INTO PRACTICE

"IN PRACTICAL MATTERS," wrote Aristotle, "the end is not mere speculative knowledge of what is to be done, but rather the doing of it." The attainment of knowledge of better methods of growing and harvesting timber, based upon research, is not enough. The job is not finished. The research man has failed to completely fulfill his obligation if he merely marks a problem "solved" when he and his associates know the answer, and file the evidence neatly away. Only when his results are packaged, distributed, and sold to his customers can he feel that his responsibility, insofar as that particular experiment is concerned, is ended. This is the final problem, the ultimate test of the effectiveness and success of his research.

In this region it will be a tough problem. It is so complex as to justify a detailed study of its own. The question to be answered: How can the facts about better forest management as determined by valid experimental study be put to work most effectively in the forest? The remoteness of so much of our best forest land represents a serious obstacle. The small woodlot owner has had little interest in doing a better job. The resistance to change is firmly embedded in our woods labor. And the ultimate success of many of the recommendations for better management could depend upon some new social concepts, such as the permanent small forest community, that industry may find very hard to accept.

Thus it is that the research forester's job is not finished with the determination of statistically significant correlations. His is also a job of education—of selling his products to his customers; if he doesn't do it, who will? Gradual and eventual adoption of the entire pattern of improved management of our forest resource by those who control it can bring a greatly strengthened industrial and social economy. Without it the region will probably remain, for decades to come, "a kind of museum piece—a relic of seventeenth-century New England inhabited by woodmen and watermen and hunters."

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A P P E N D I X

Table No.		Page
1.	Area and population statistics . . .	62
2.	Agricultural statistics	63
3.	Industrial summary	64
4.	Summary of wood-using industries . .	65
5.	Principal sources of employment . .	66
6.	Industrial statistics	67
7.	Estimated volume of timber	68
8.	Operating drain on timber	69
9.	Cost of procuring pulpwood	70

Table 1.--Area and population statistics for spruce-fir region of Maine

(1940 Census)

County	Land area	Forest area	Population							
			Total	Per square mile	Increase 1930-40	Urban[1]		Increase 1930-40	Rural	Increase 1930-40
	Square miles	Square miles	Number	Number	Percent	Number	Percent	Percent	Number	Percent
Aroostook	6,805	5,715	94,436	13.9	7.5	8,149	8.6	12.0	86,287	7.1
Franklin	1,717	1,408	19,896	11.6	- 0.2	None	0.0	--	19,896	- 0.2
Hancock	1,542	1,311	32,422	21.0	5.5	3,911	12.1	10.0	28,511	5.0
Oxford[2]	1,042	823	21,330	20.5	2.8	4,223	19.8	- 3.2	17,107	4.5
Penobscot	3,408	2,658	97,104	28.5	5.1	44,020	45.3	4.0	53,084	6.1
Piscataquis	3,948	3,553	18,467	4.7	1.3	None	0.0	--	18,467	1.3
Somerset	3,948	3,277	38,245	9.7	- 2.2	6,001	15.7	- 8.6	32,244	- 0.9
Washington	2,563	2,255	37,767	14.8	- 0.2	8,507	22.5	- 4.8	29,260	1.3
Total	24,973	21,000	359,667	--	--	74,811	--	--	284,856	--

[1] Living in incorporated places of 2,500 or more.

[2] Including only 50 percent of the county.

Table 2.--Agricultural statistics for spruce-fir region of Maine

(1940 Census)

County	Approx. land area	Land in farms		Number and average size of farms		Farm woodland	
						Farms reporting	Woodland area, 1939
	Acres	Acres	Percent	Number	Acres	Number	Acres
Aroostook	4,355,200	793,218	18.2	5,706	139	4,591	270,380
Franklin	1,098,880	185,732	16.9	1,469	126	1,236	94,276
Hancock	986,880	158,117	16.0	1,804	88	1,432	83,904
Oxford	1,334,400	308,485	23.1	2,509	123	2,003	169,288
Penobscot	2,181,120	445,185	20.4	3,932	113	3,024	186,308
Piscataquis	2,526,720	138,208	5.5	977	142	819	70,156
Somerset	2,526,720	376,936	14.9	2,863	132	2,376	174,419
Washington	1,633,920	291,163	17.8	2,358	124	1,698	139,165
Total	16,643,840	2,697,044	16.2	21,618	125	17,179	1,187,896

Table 3.—Industrial summary for Maine, 1947

Industry or industry group	Value of product	Payroll	Number of employees
Boot and shoe	$102,618,000	$ 27,076,000	16,934
Textiles	248,290,000	61,992,000	30,977
Food processing	97,445,000	15,080,000	17,692
Metals, machinery, etc.	64,963,000	25,365,000	9,715
Shipbuilding (iron)	18,168,000	22,656,000	7,636
Printing and publishing	7,085,000	3,705,000	1,606
Miscellaneous industries	61,122,000	10,114,000	5,556
Pulp and paper	211,120,000	47,175,000	16,976
Lumber	26,477,000	7,859,000	4,707
Other wood products	43,482,000	15,031,000	7,987
Total	$880,770,000	$236,053,000	119,786
Agriculture[1]	$110,309,000	$ 18,516,000	41,745
All primary forest products	$281,079,000	$ 70,065,000	29,670

[1] U. S. Bureau of the Census, 1945.

Table 4.--Summary of active wood-using industries in spruce-fir region of Maine, by counties, 1947

County	Sawmills	Turneries	Bolt mills	Shingle mills	Pulp & paper	Cooperage	Plywood	Poles	Total
Aroostook	52	1	2	1	1	7	1	1	66
Franklin	20	16	1	2	2	--	--	--	41
Hancock	34	3	2	2	1	1	--	--	43
Oxford	73	20	9	2	1	--	--	--	105
Penobscot	58	6	3	3	7	3	2	--	82
Piscataquis	17	5	3	2	--	1	1	--	29
Somerset	38	12	9	1	3	--	1	--	64
Washington	29	1	3	3	1	--	--	--	37
Total	321	64	32	16	16	12	5	1	467

Source: Baker, Gregory. THE PRIMARY WOOD-USING INDUSTRIES OF MAINE. Maine Agr. Expt. Sta. Bul. 448. 1947.

Table 5.--Principal sources of employment in spruce-fir region of Maine, by counties

(1940 Census)

Item	County								Total
	Aroostook	Franklin	Hancock	Oxford	Penobscot	Piscataquis	Somerset	Washington	
Labor force	30,390	7,844	11,555	16,426	35,867	6,817	14,762	14,146	137,807
No. employed in:									
Agriculture	9,014	1,318	1,138	2,283	3,727	822	2,486	1,366	22,154
Forestry & fishery	46	9	577	10	35	10	11	690	1,388
Construction	804	268	817	455	1,303	204	401	390	4,732
Food mfg.	207	44	167	127	425	13	109	1,036	2,128
Textiles mfg.	7	603	11	283	967	450	1,009	31	3,361
Logging	706	692	272	949	926	323	614	447	4,929
Sawmills & planing mills	548	301	97	363	481	261	270	311	2,632
Furniture & misc. wooden goods mfg.	43	897	29	1,273	271	432	259	48	3,252
Paper & allied prod. mfg.	479	365	442	2,420	3,173	54	720	399	8,052
Railroads & Rwy. Exp.	662	29	62	142	1,046	647	243	227	3,058
Trucking service	257	95	116	132	382	84	133	103	1,302
Communications	175	47	105	76	307	47	78	73	908

Table 6.--Industrial statistics for spruce-fir region of Maine

(1939 Census of Manufacturers)

County	Manufacturing establishments	Wage earners	Wages	Cost of materials, fuel, electricity, & contract work	Value of product	Value added by mfg.
	Number	Number	Dollars	Dollars	Dollars	Dollars
Aroostook	73	2,195	1,790,084	8,349,541	13,170,135	4,820,594
Franklin	43	2,698	2,378,097	6,063,484	10,748,999	4,685,515
Hancock	26	1,033	1,180,504	5,837,243	9,773,408	3,936,165
Oxford	84	5,193	4,962,501	16,215,926	25,452,834	9,236,908
Penobscot	127	5,999	6,422,171	23,423,605	41,883,725	18,460,120
Piscataquis	30	1,284	982,427	1,658,923	3,711,124	2,052,201
Somerset	86	3,708	3,094,438	8,099,371	14,474,978	6,375,607
Washington	74	2,518	1,487,450	6,626,149	11,047,650	4,421,501

Table 7.—Estimated volume of timber in Maine, by species or groups of species

(From Sewall's report of 1944)

Species	Operable	Not operable	Total
	Cords	Cords	Cords
Spruce and fir	27,189,200	10,673,000	37,862,200
Hemlock	3,882,200	1,170,000	5,052,200
Hardwood pulpwood and fuel wood	83,463,000	15,356,500	98,819,500
White birch	1,693,000	476,600	2,169,600
Poplar	1,994,000	557,900	2,551,900
	MBF	MBF	MBF
Cedar	1,045,650	346,650	1,392,300
Red and white pine	3,360,050	878,100	4,238,150
Hardwood logs	2,394,925	718,295	3,113,220

Table 8.--Operating drain on timber in Maine, by species and products, 1949

(Based on Maine Forest Service information)

Species	Entire State		Spruce-fir region	
	Lumber	Pulpwood	Lumber	Pulpwood
	MBF	Cords	MBF	Cords
Pine	292,475	60,828	91,495	20,723
Spruce and fir	70,938	882,532	55,514	801,137
Hemlock	75,223	107,278	17,377	83,067
Other softwoods	4,064	--	3,871	--
Birch[1]	60,058	--	45,394	--
Maple	16,738	--	14,874	--
Beech	6,215	--	5,154	--
Poplar	114	79,897	80	77,026
Other hardwoods	9,776	--	5,738	--
Mixed hardwoods (not classified)	1,903	145,448	930	104,428
Total	537,504	1,275,983	240,427	1,086,381

[1] Includes boltwood.

Table 9.--Cost of procuring rough pulpwood: comparison of company operation, contractor, and direct purchase, 1948

(Per-cord basis)

Item	Company camp	Contractor camp	Purchased wood[1]
General expense:			
Administration	$ 1.00	$ 0.50	$ 0.10
Taxes	1.30	1.00	—
Insurance	.70	.70	—
Maintenance	.50	.50	—
Fire protection	.05	.05	—
Scaling, cruising, etc.	.50	.50	.10
Miscellaneous	1.20	.10	—
Total	$ 5.25	$ 3.35	$ .20
Cutting:			
Camp construction	$ .50	—	—
Swamping	1.00	—	—
Cutting & yarding (labor)	4.50	—	—
Horse labor & feed	.70	—	—
Supervision	.70	—	—
Overtime	.50	—	—
Miscellaneous	.80	—	—
Total	$ 8.70	$ 8.25[2]	—
Hauling to river:			
Labor	$ 2.00	—	—
Rental charge for equip.	1.50	—	—
Depreciation of equip.	.40	—	—
Miscellaneous	1.10	—	—
Total	$ 5.00	$ 4.25[2]	—
River drive	1.50	1.00	—
Contractor's salary & profit	—	1.15	—
Stumpage	4.00	4.00	—
Price of purchased wood	—	—	16.00
Total cost, wood delivered at mill	$24.45	$22.00	$16.20

[1] "Purchased wood" here refers to wood purchased locally in small lots by company dealers, or trucked directly to the mill by small woodlot owners.

[2] Breakdown of total not available.